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Zdroik et al.

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(54) FUEL INJECTOR RETENTION CLIP

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(73) Assignee: **Millennium Industries Corp.**, Auburn Hills, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/835,186**

(22) Filed: **Aug. 7, 2007**

(65) **Prior Publication Data**

US 2007/0266996 A1 Nov. 22, 2007

Related U.S. Application Data

(60) Division of application No. 11/361,550, filed on Feb. 24, 2006, now Pat. No. 7,360,524, which is a continuation-in-part of application No. 11/003,059, filed on Dec. 3, 2004, now Pat. No. 7,159,570.

(51) **Int. Cl.**
F02M 61/14 (2006.01)

(52) **U.S. Cl.** **123/470**; 123/469; 239/600

(58) **Field of Classification Search** 239/600; 123/468, 470, 469
See application file for complete search history.

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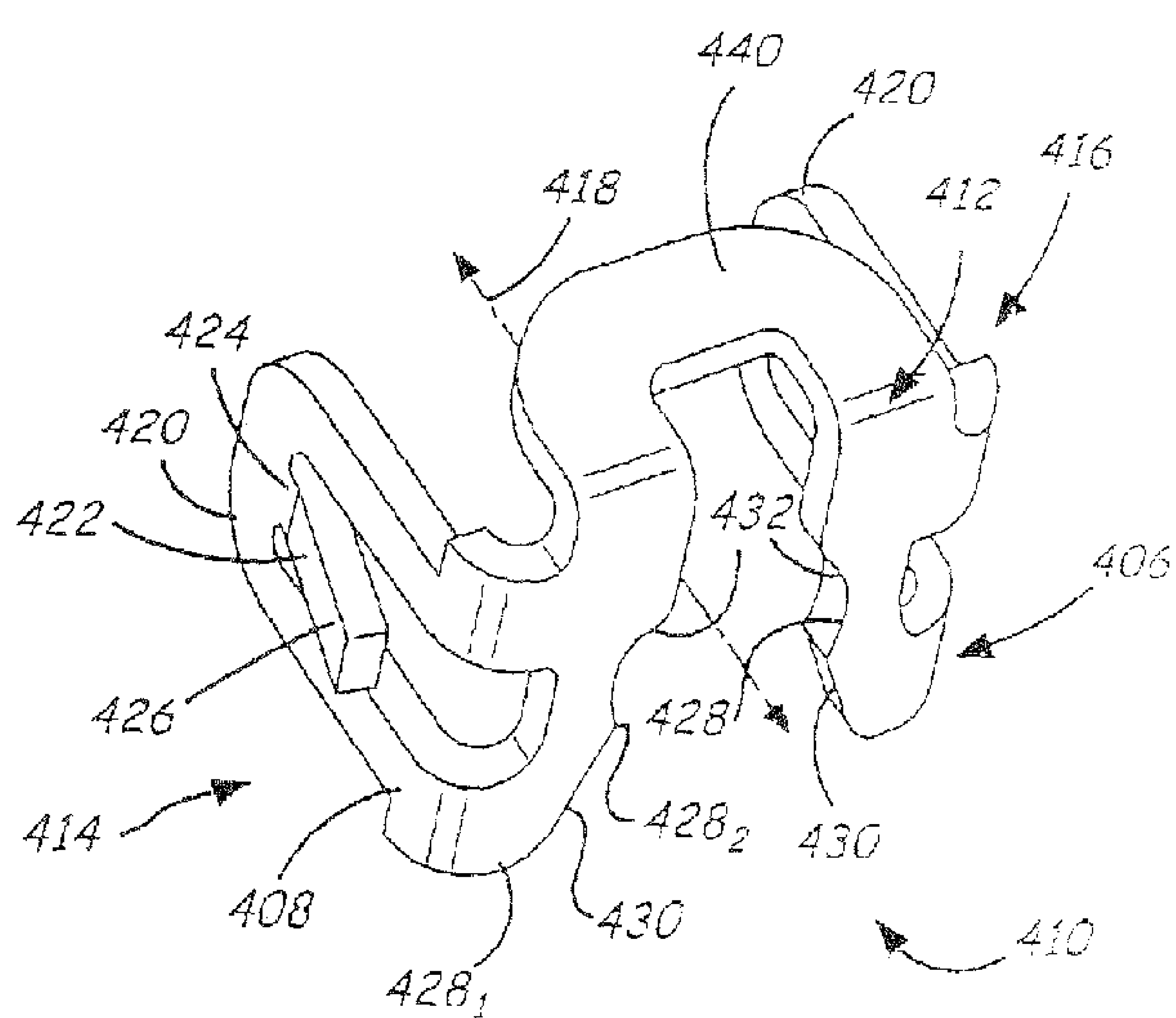
(57) **ABSTRACT**

A fuel delivery system in accordance with the present invention comprises a fuel rail having an outlet opening and an outlet cup that is insertable into the outlet opening. The cup includes a flange. The flange includes at least one tab extending therefrom. The cup further defines a vertical axis extending therethrough. The system further includes a fuel injector with an inlet insertable within the cup. The system still further includes a retention clip. The clip includes an inner peripheral surface, at least a portion of which is configured for engagement with the injector when the clip and injector are assembled together. The clip further includes at least one arm, the arm further including a finger configured for spring engagement with the tab of the cup. The clip is operative to limit the movement of the fuel injector when it is assembled with the clip and inserted in the cup.

13 Claims, 15 Drawing Sheets



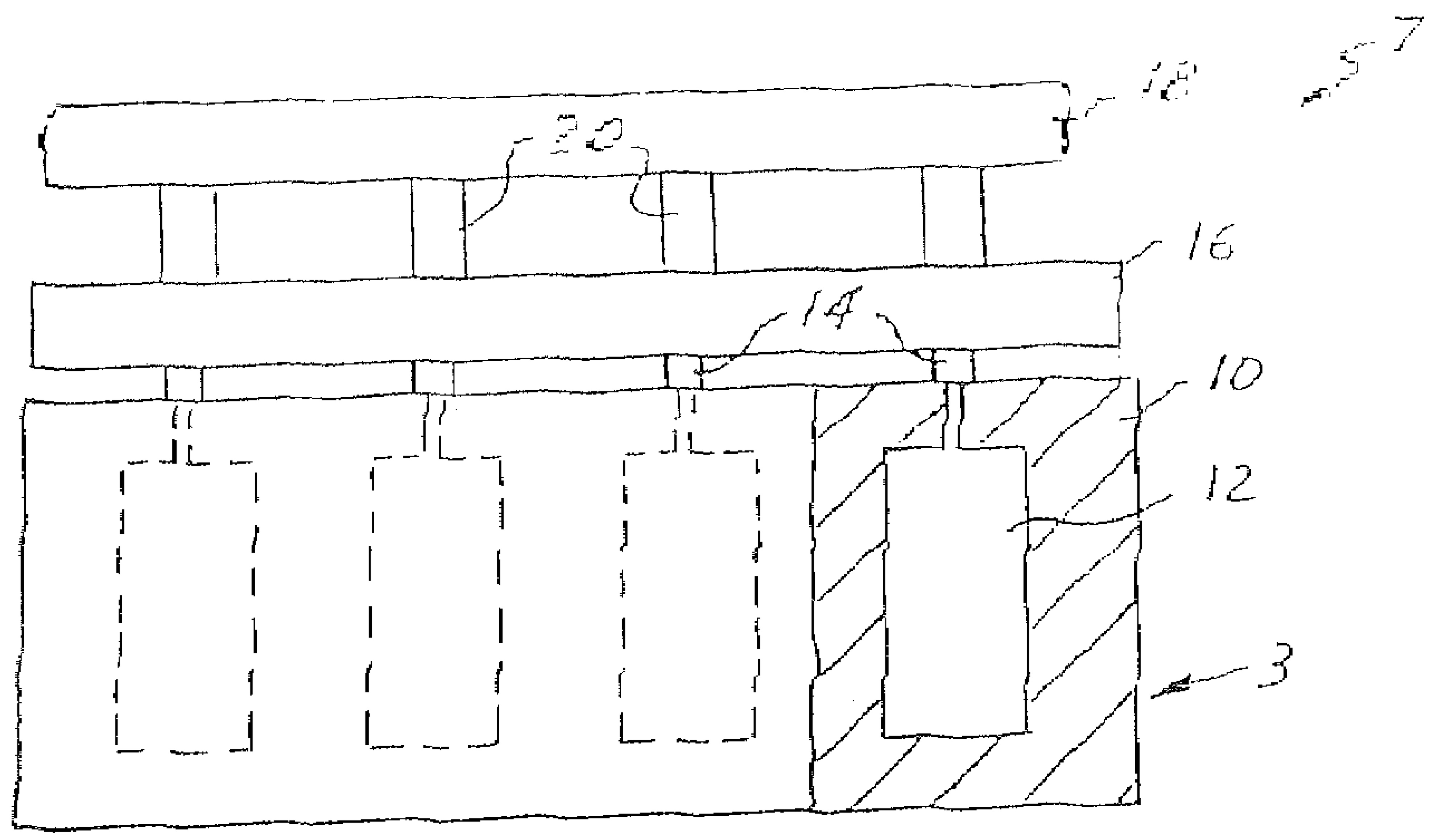


FIG. 1

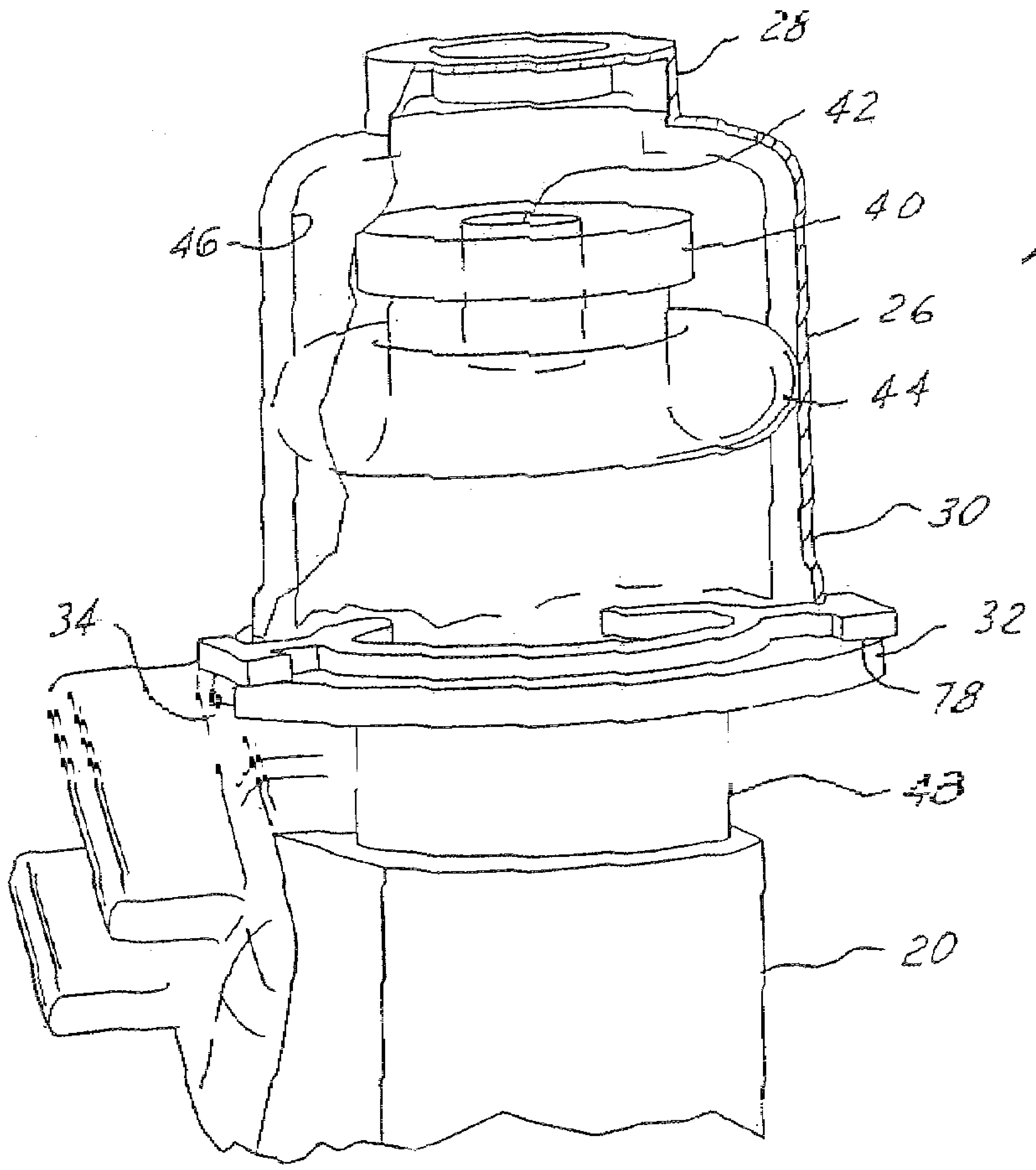


FIG. 2

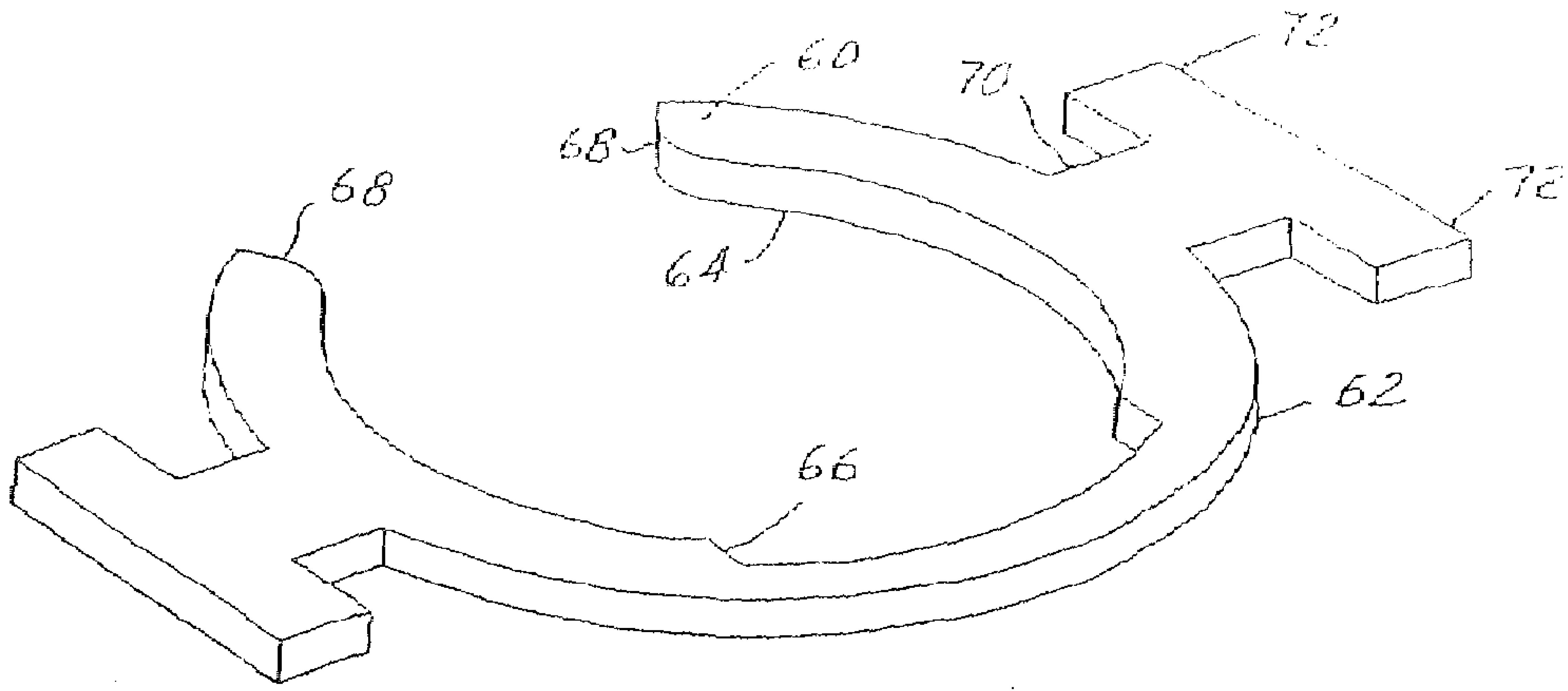


FIG. 4

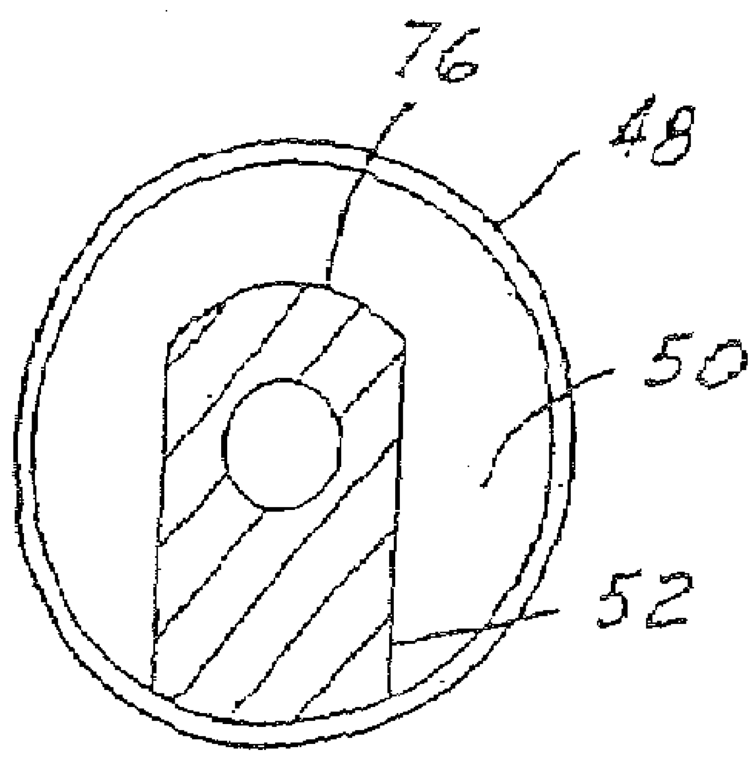


FIG. 3

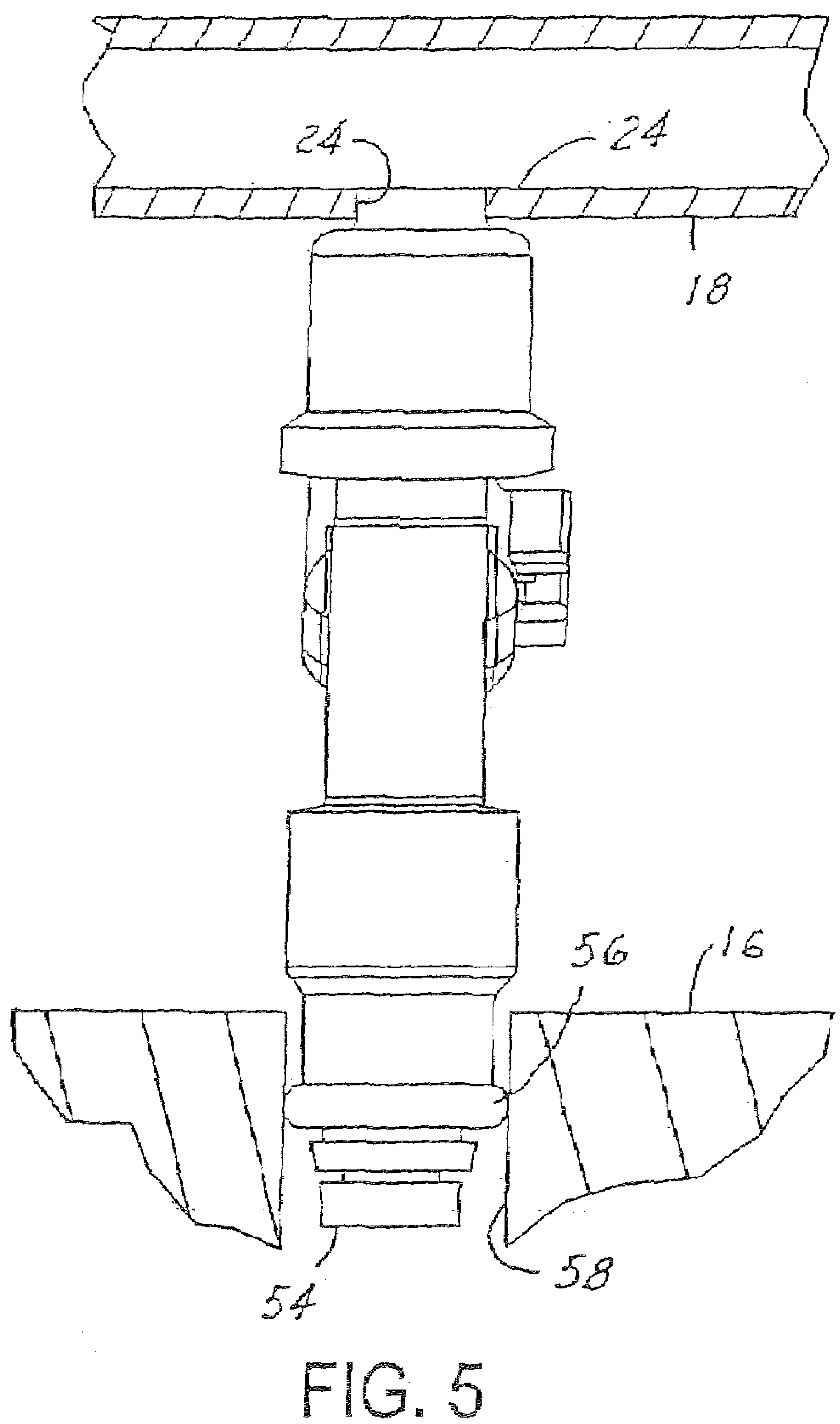
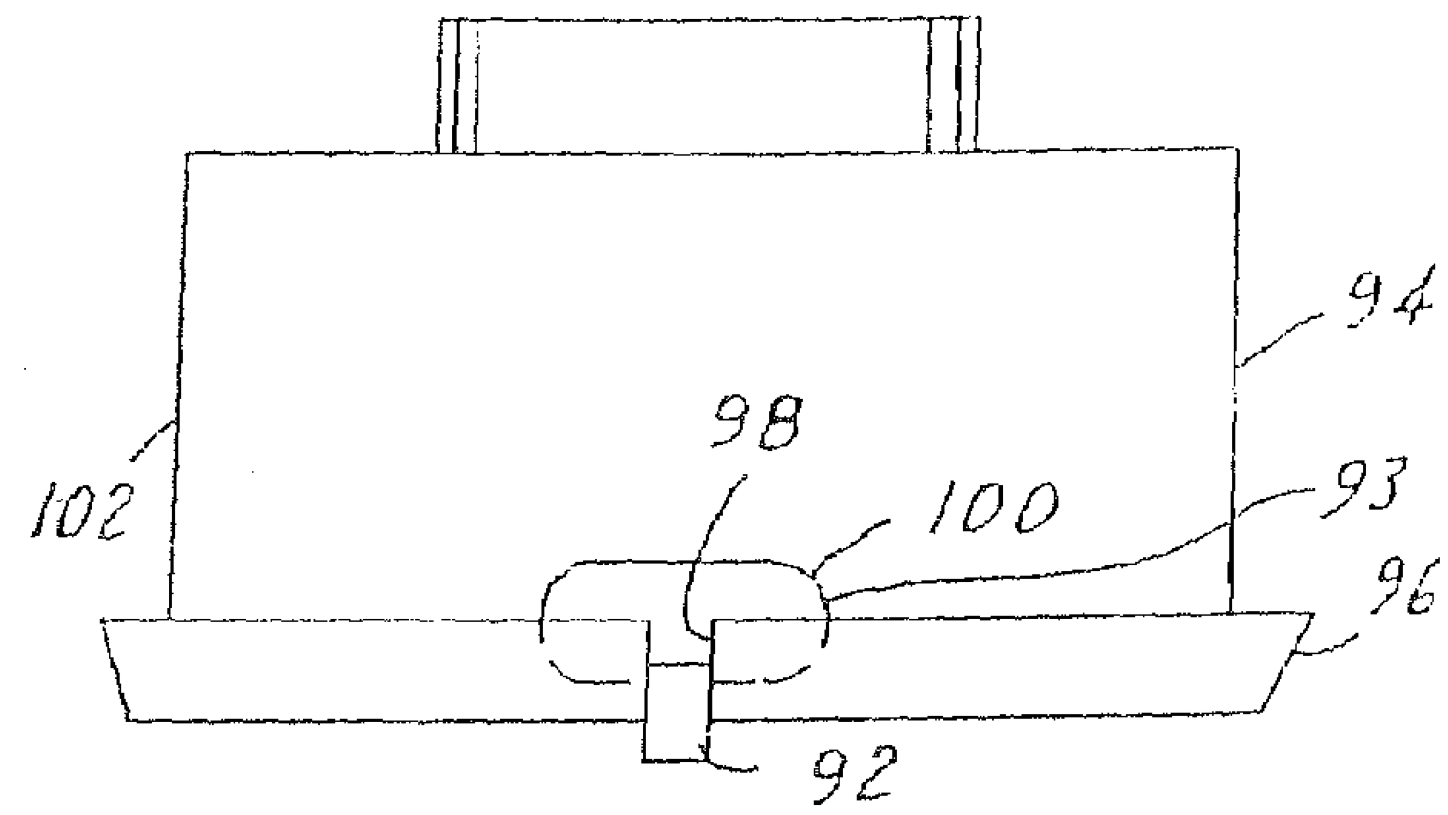


FIG. 5



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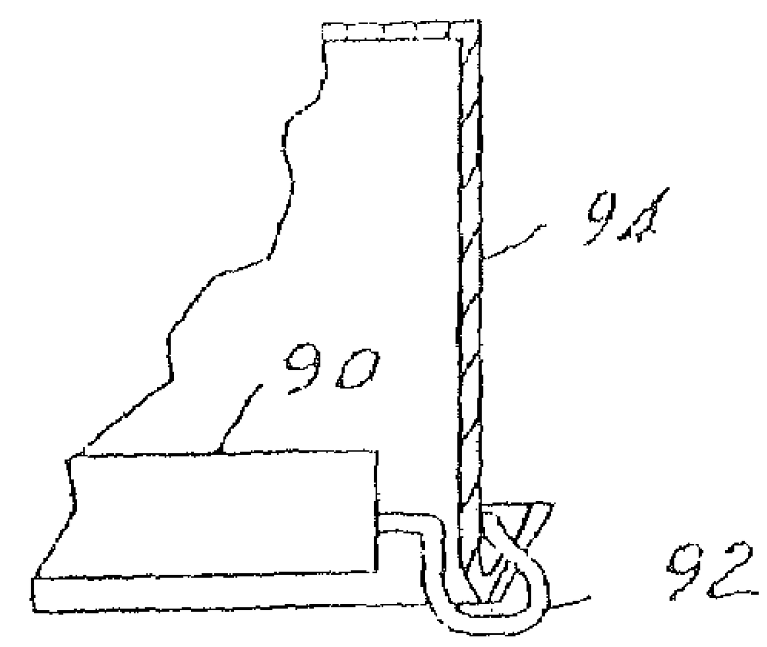

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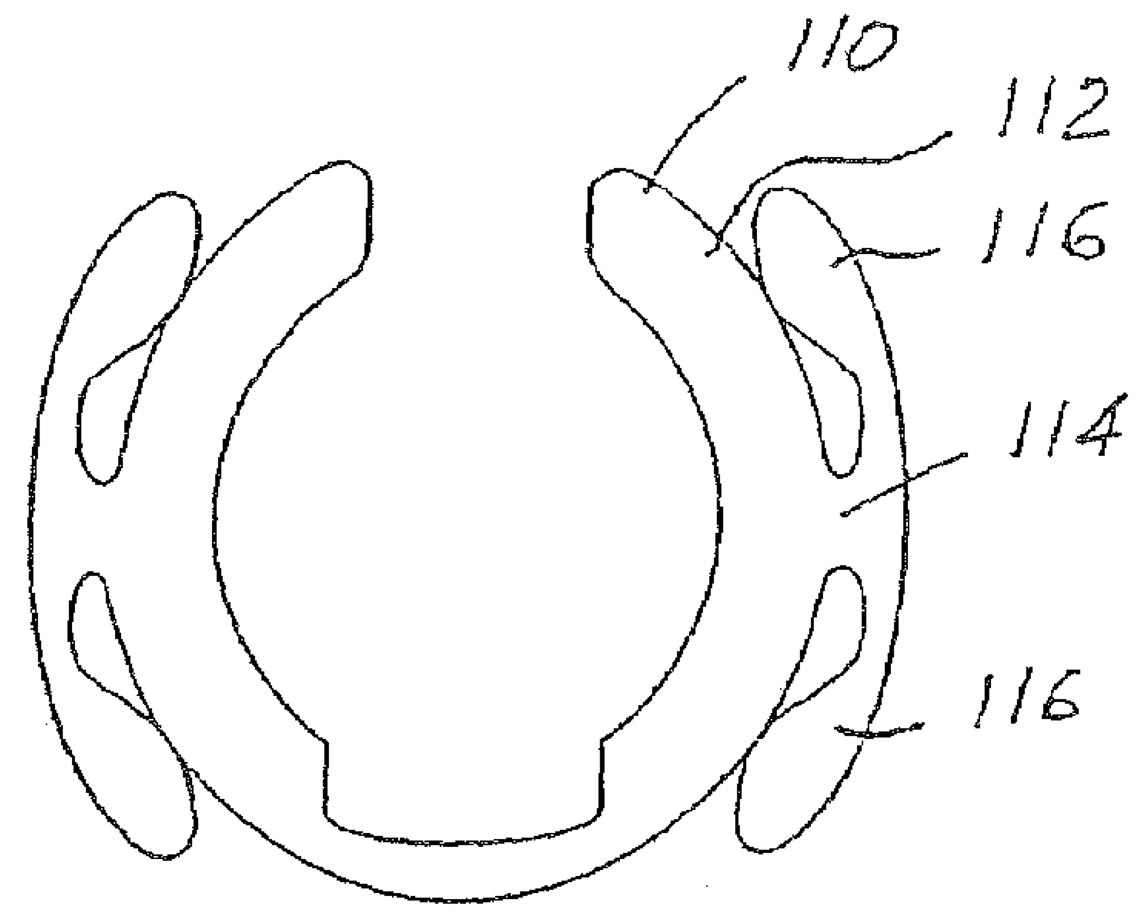

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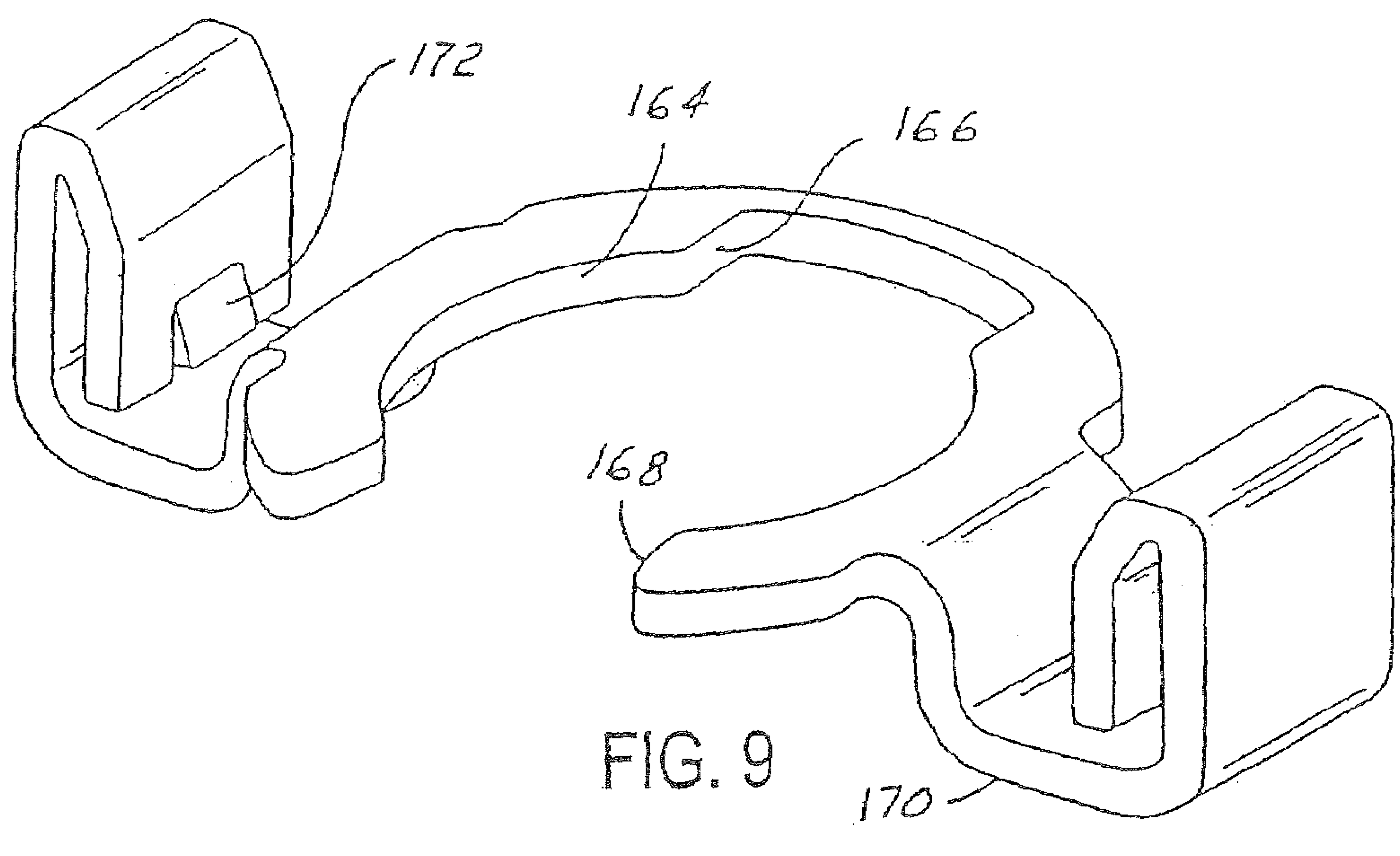

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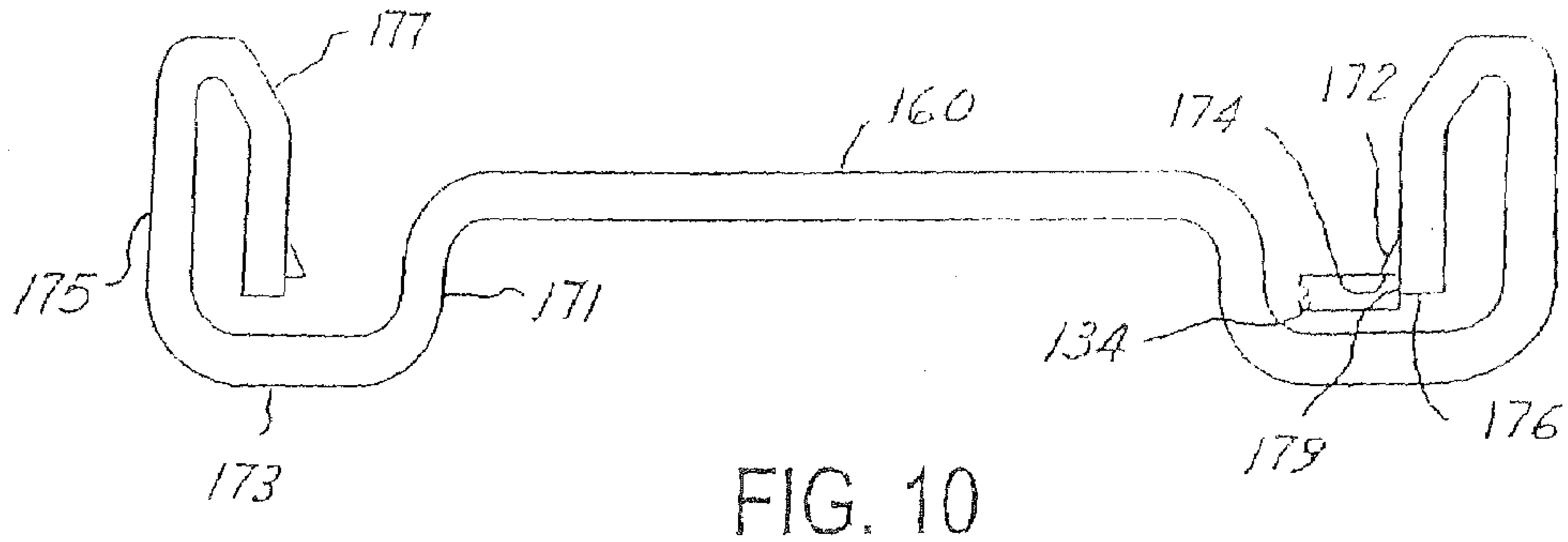

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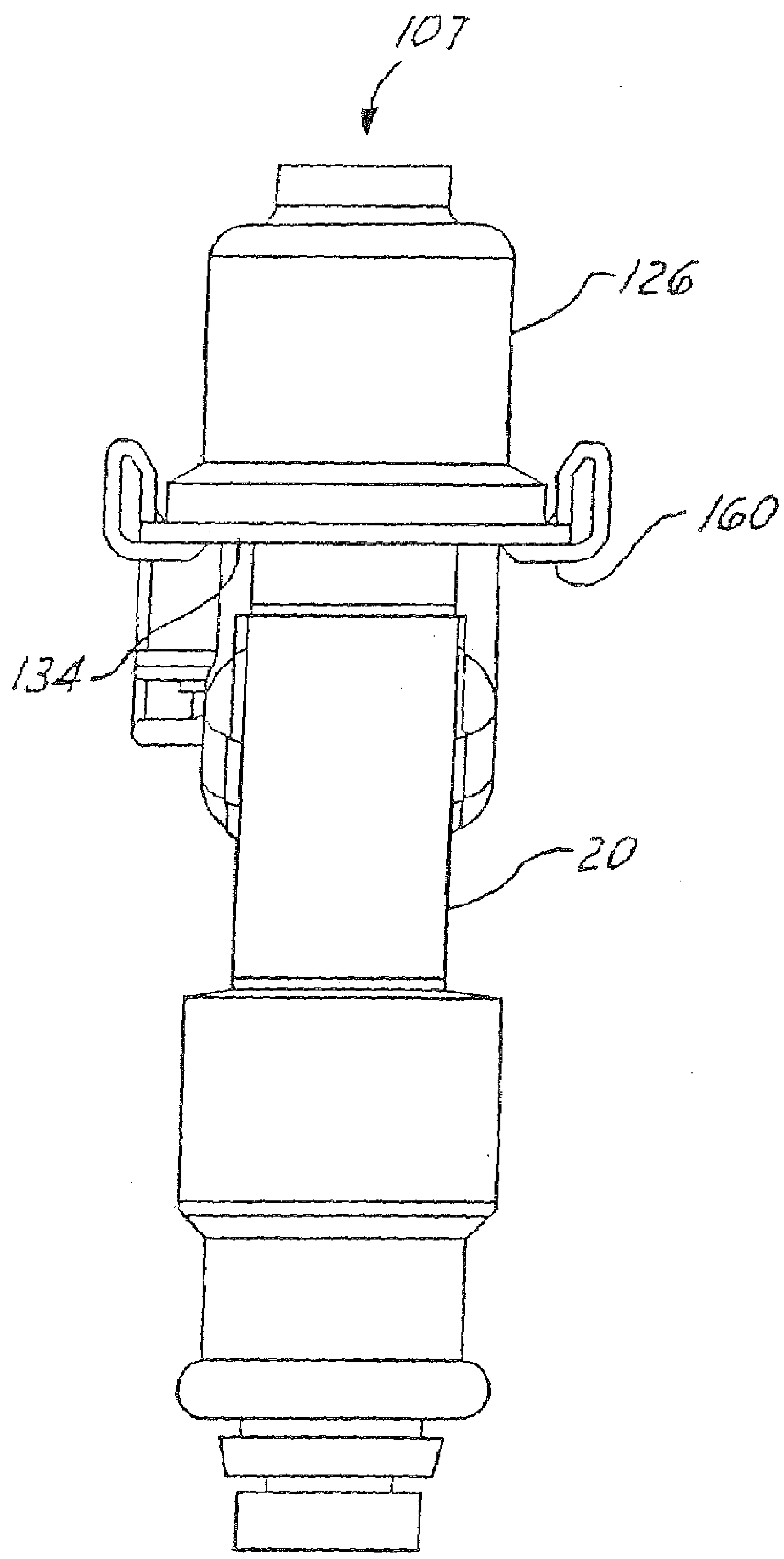


FIG.11

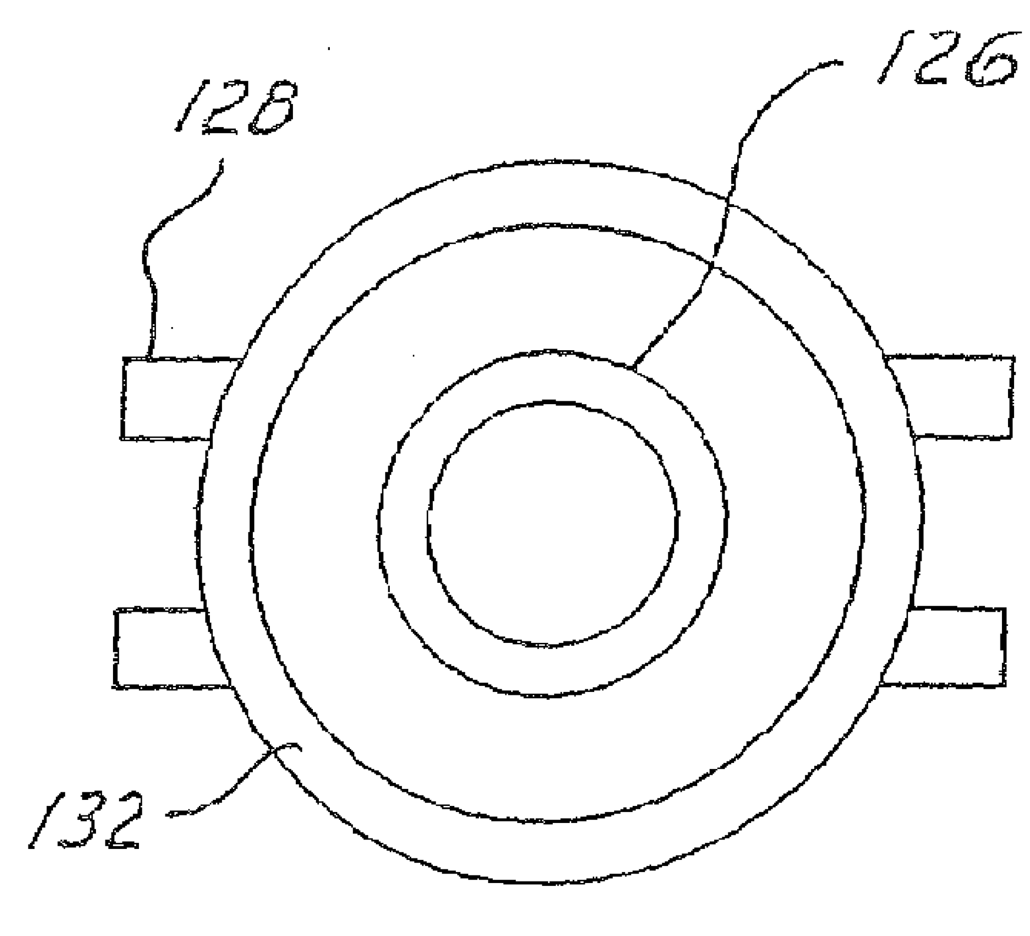
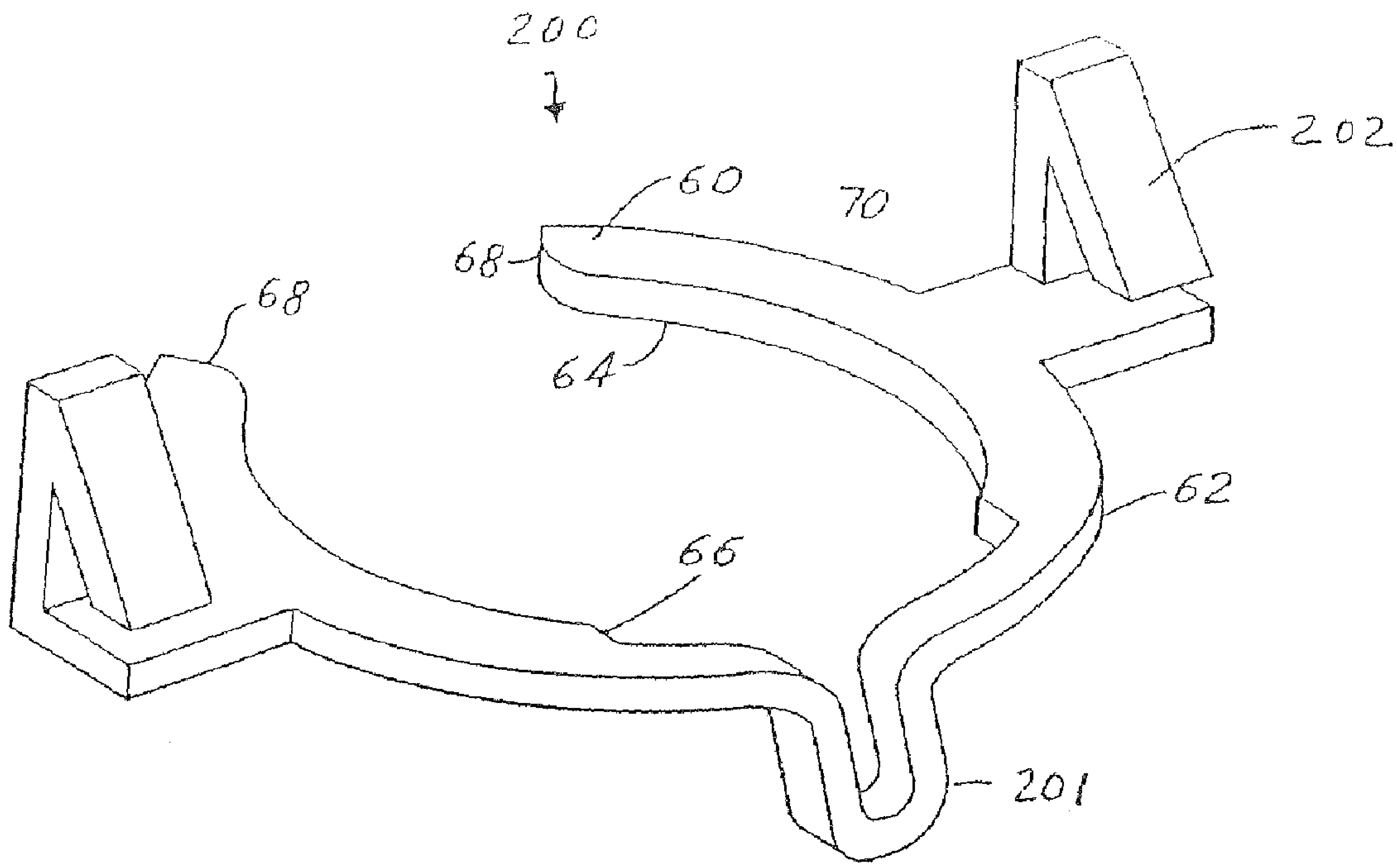


FIG. 12



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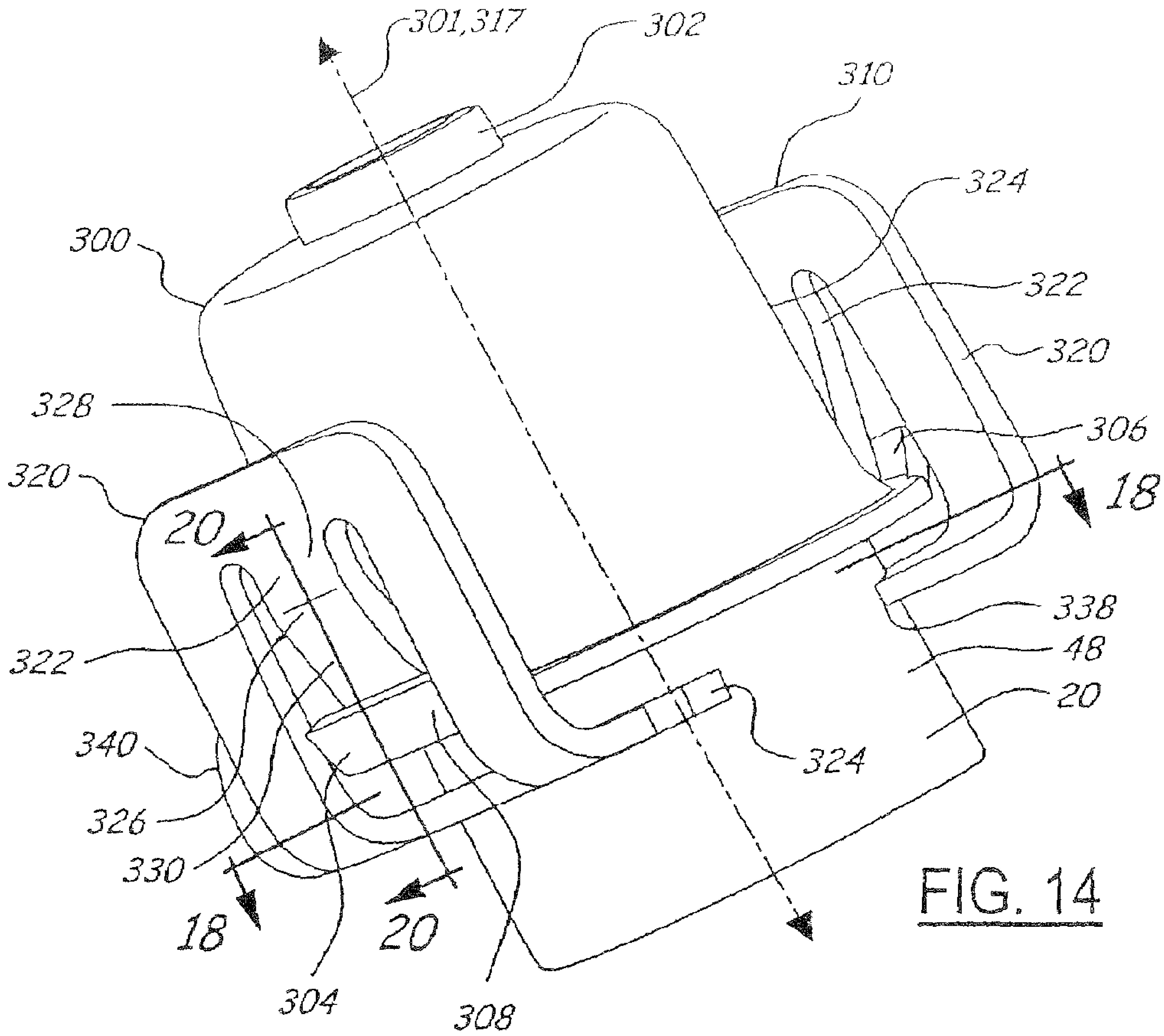
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FIG. 14

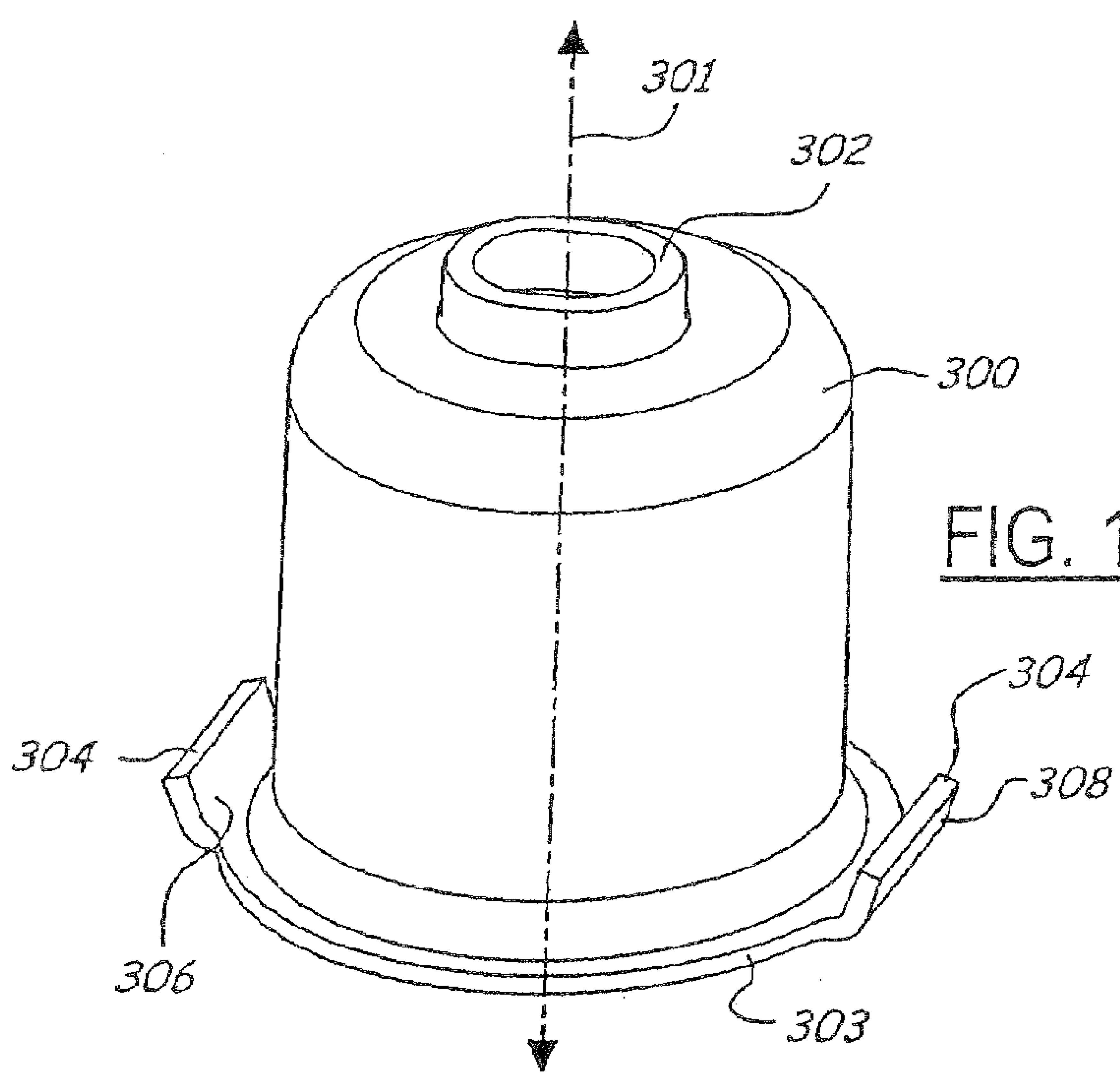
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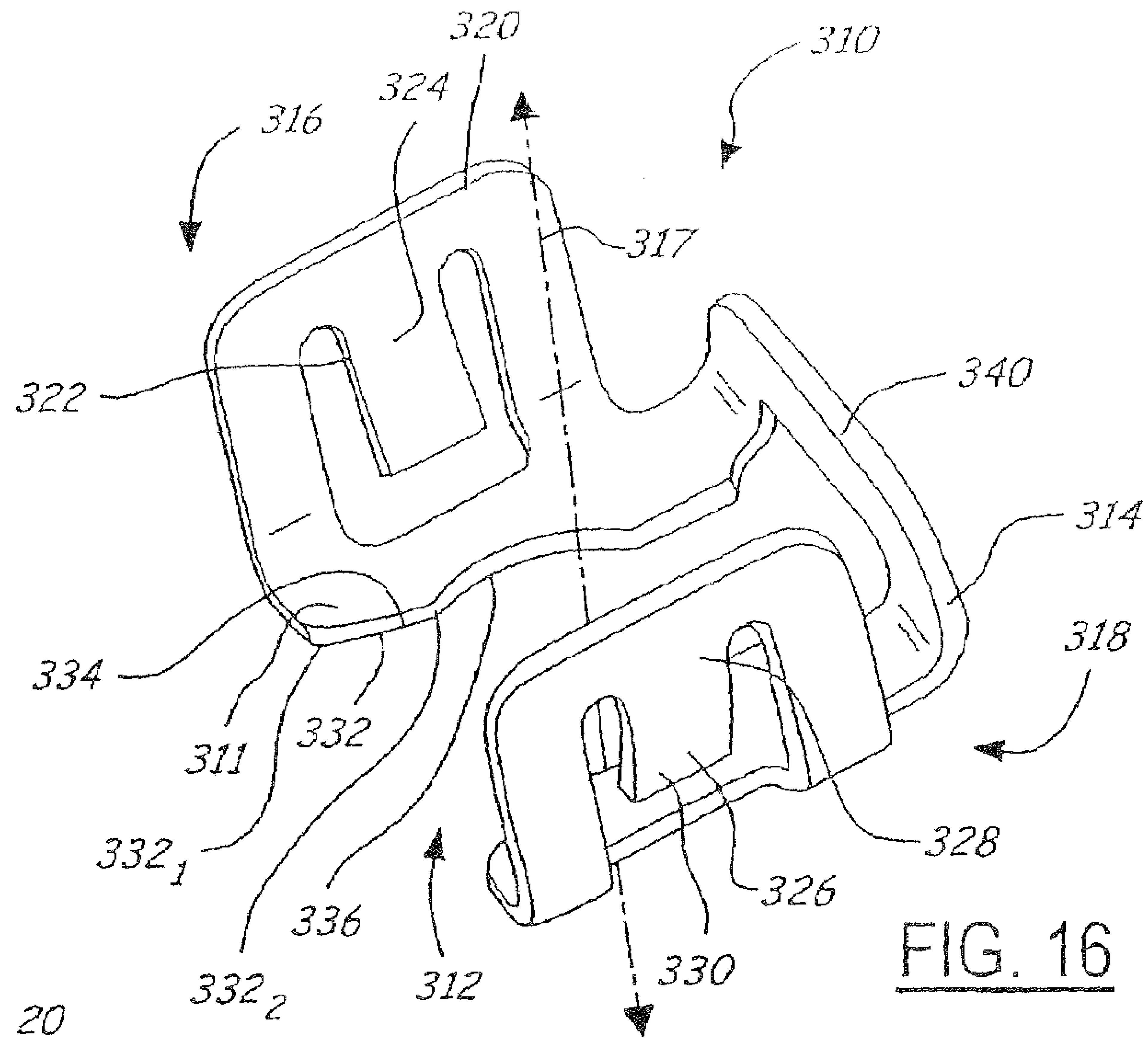
FIG. 15



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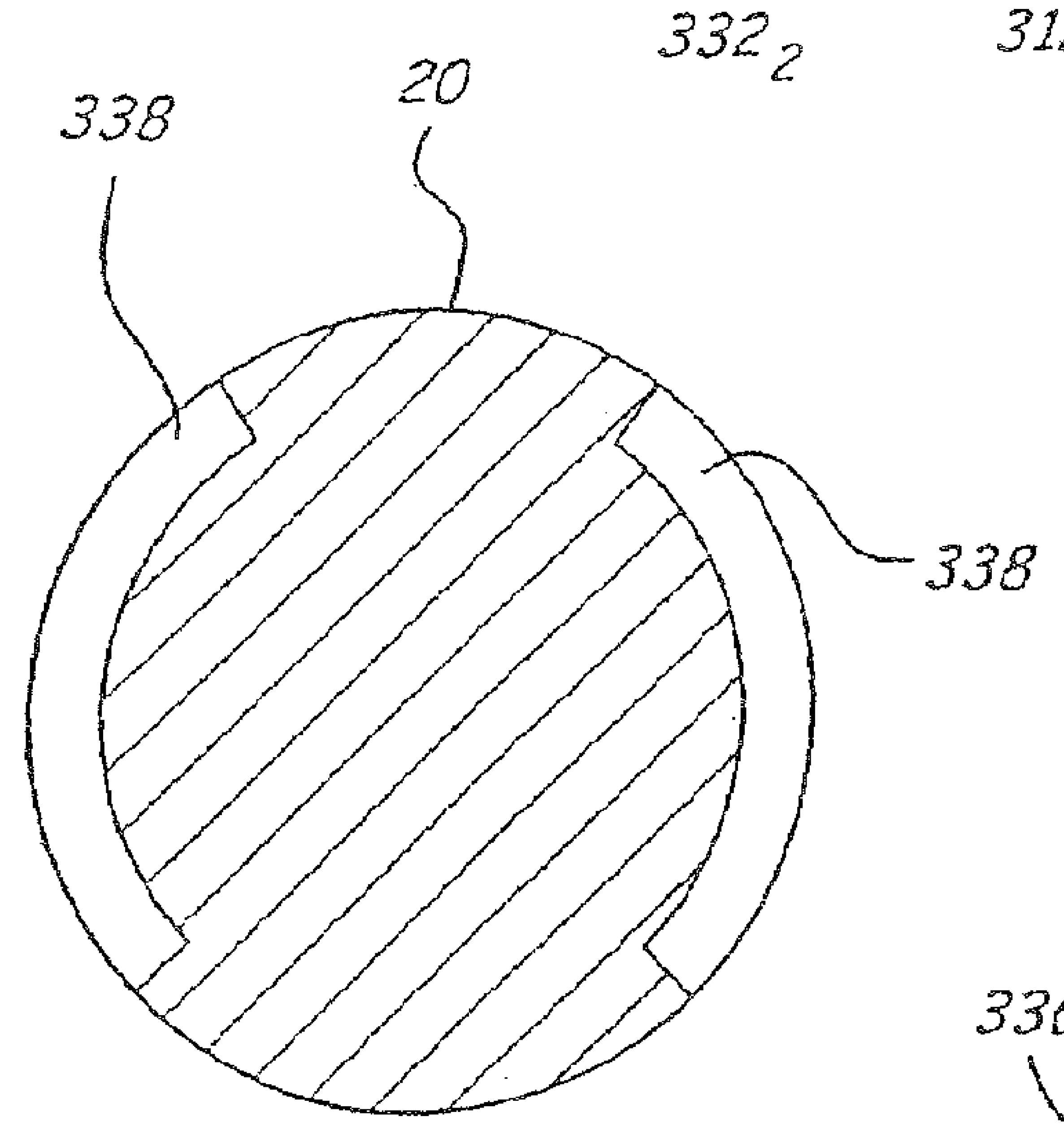

FIG. 17a

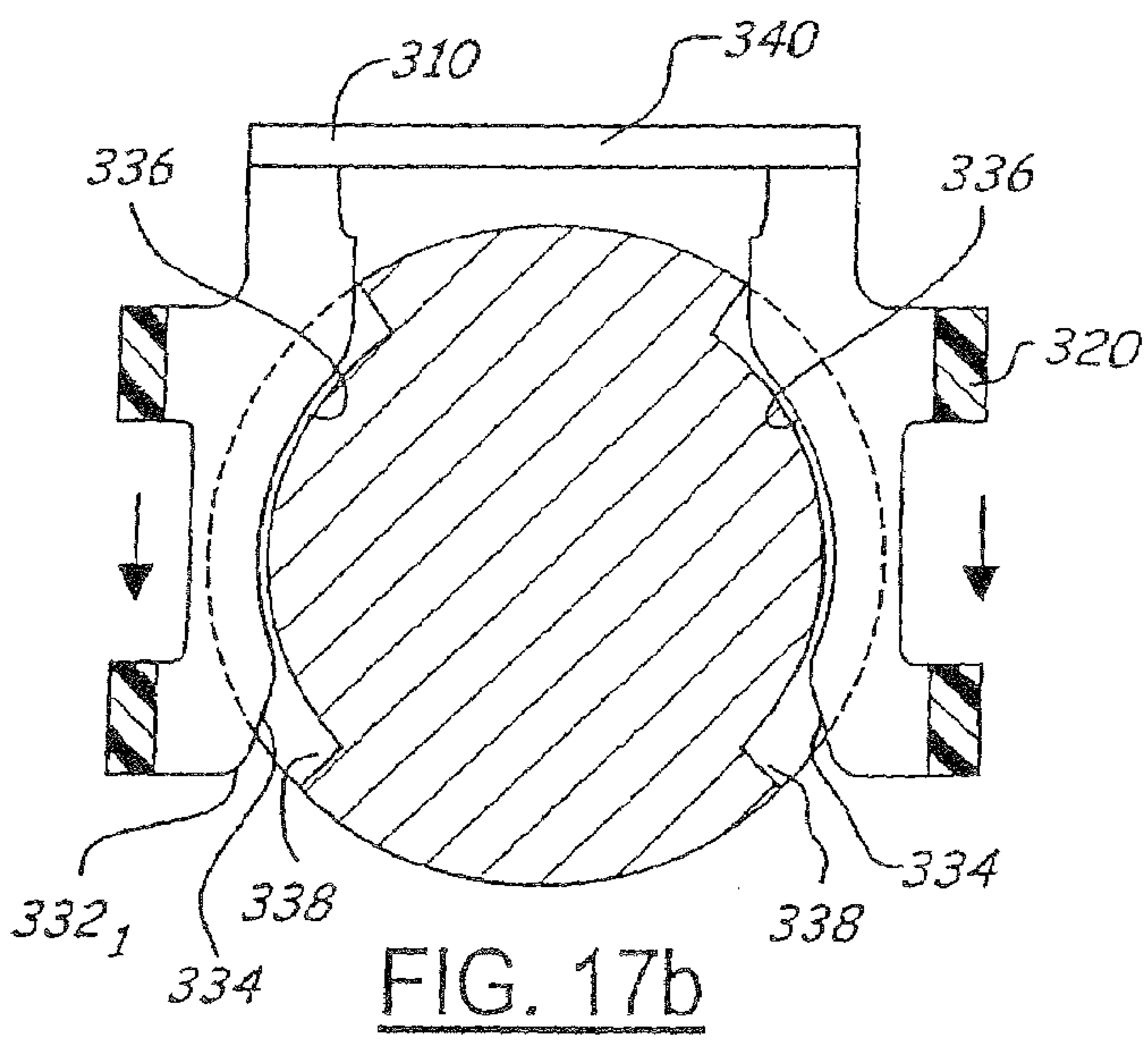

FIG. 17b

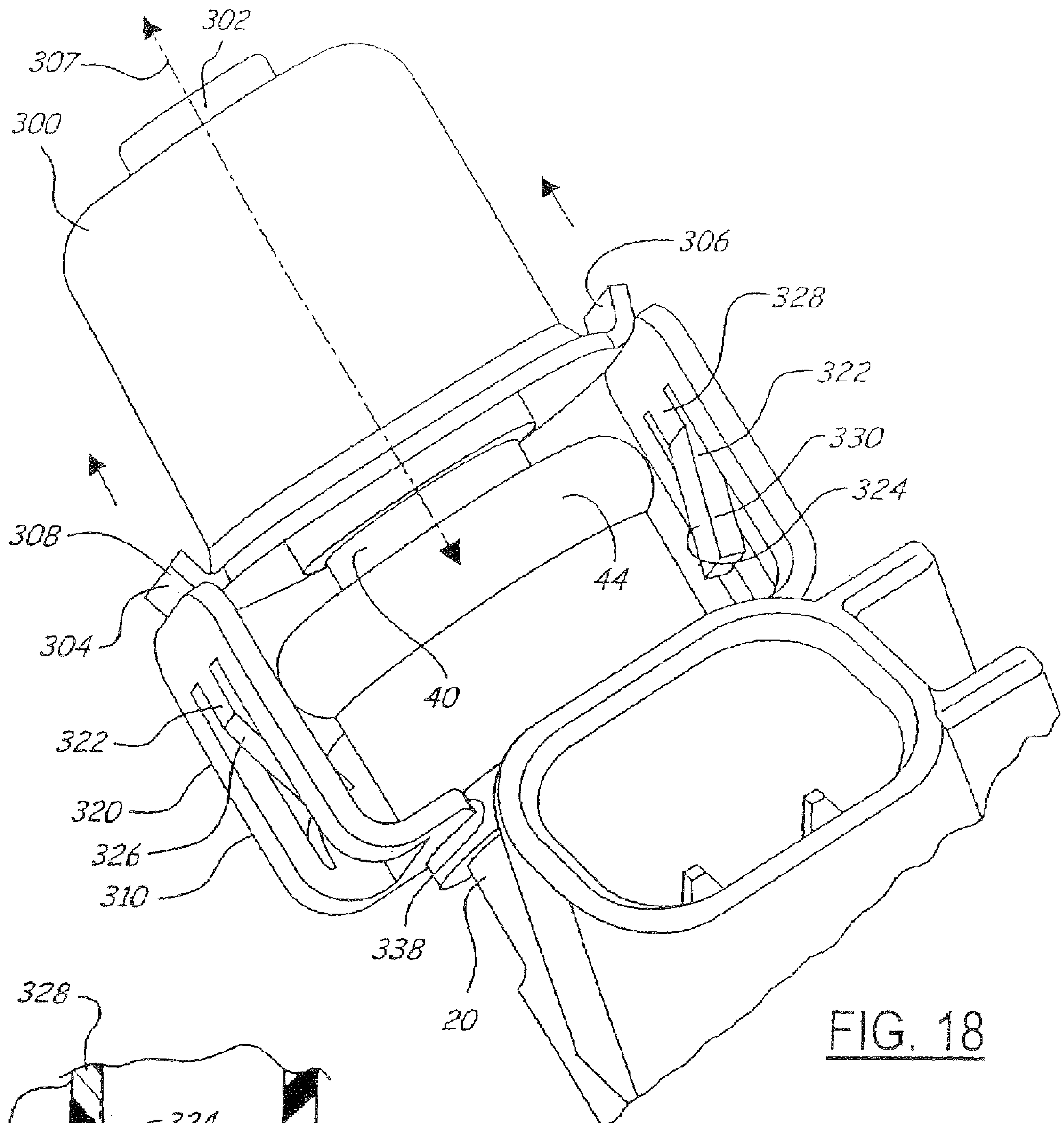
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FIG. 18

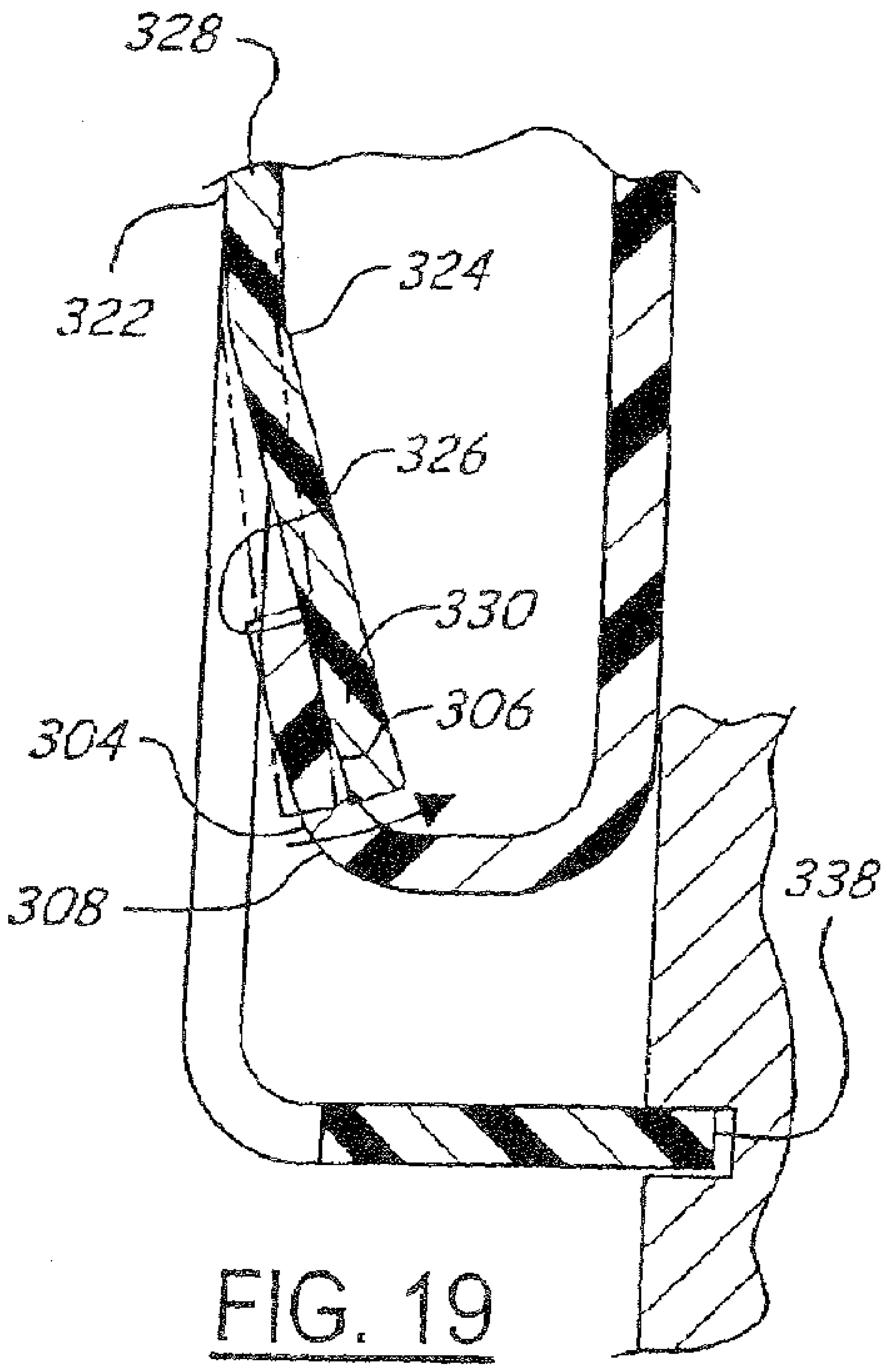
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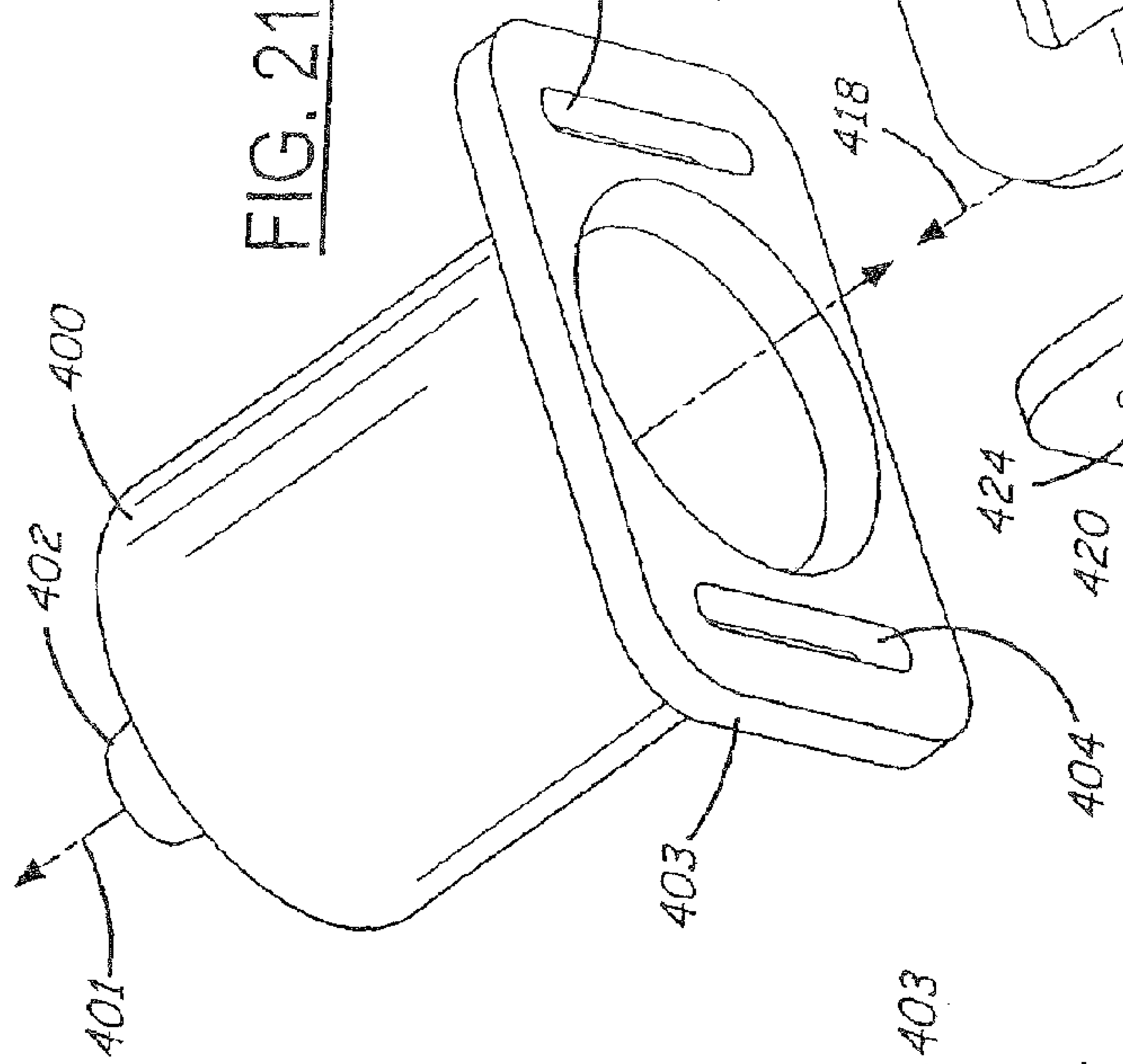
FIG. 19



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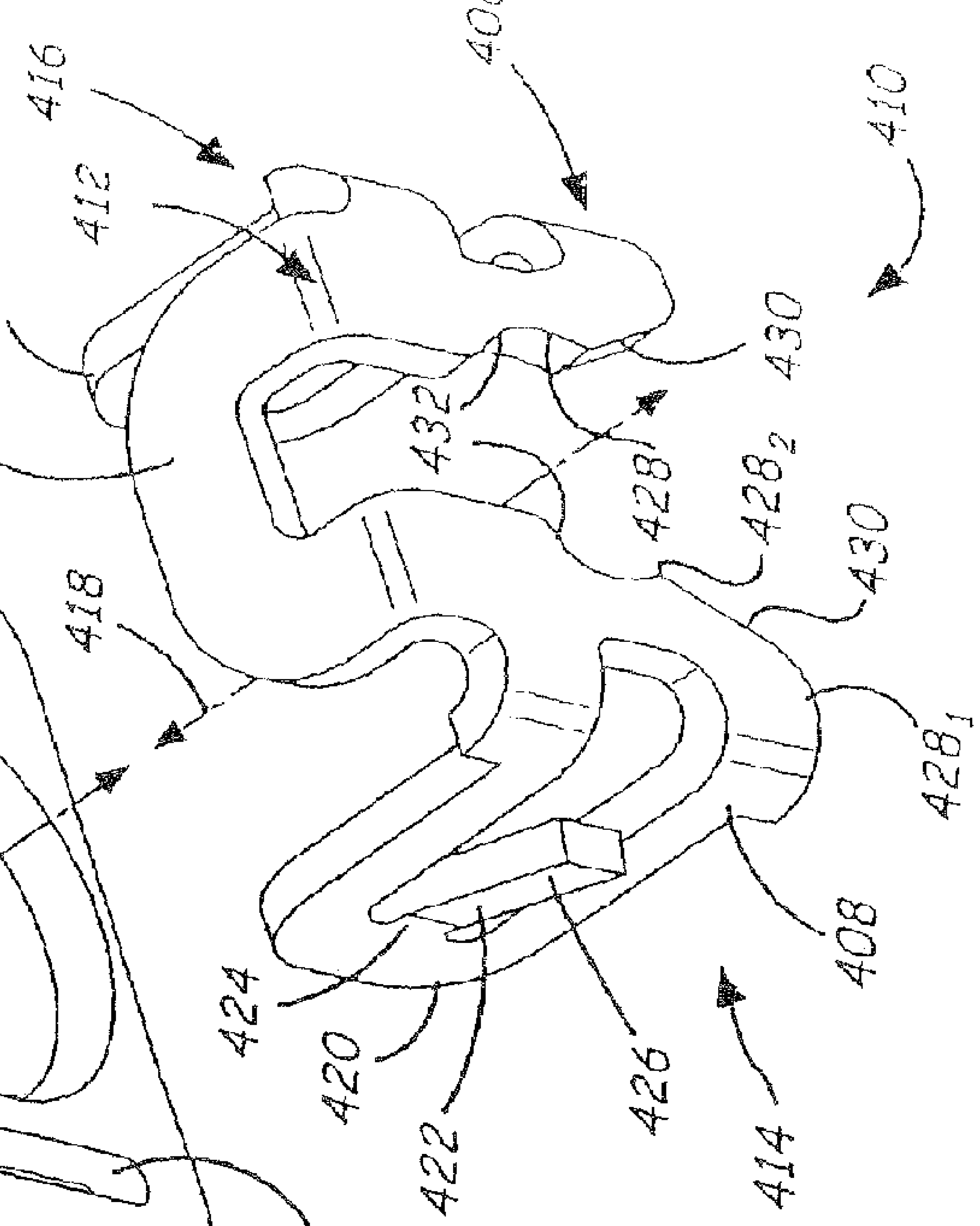
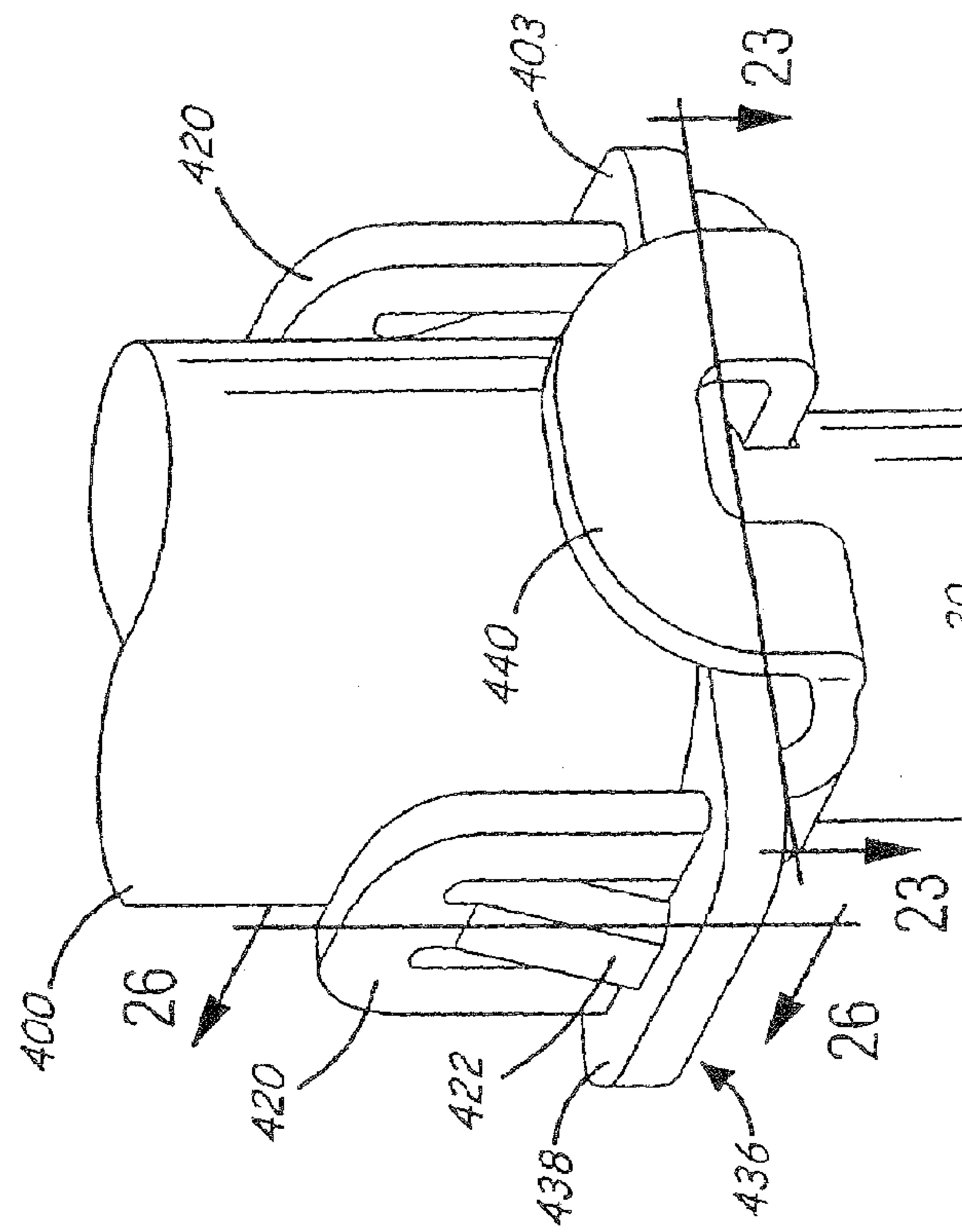


FIG. 22



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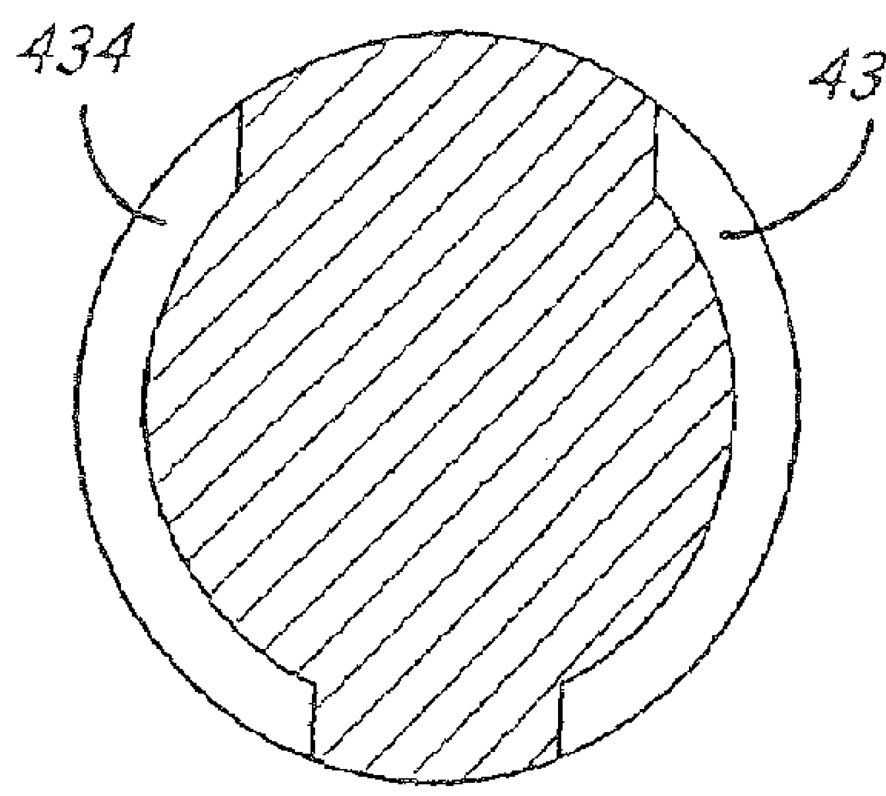

FIG. 23a

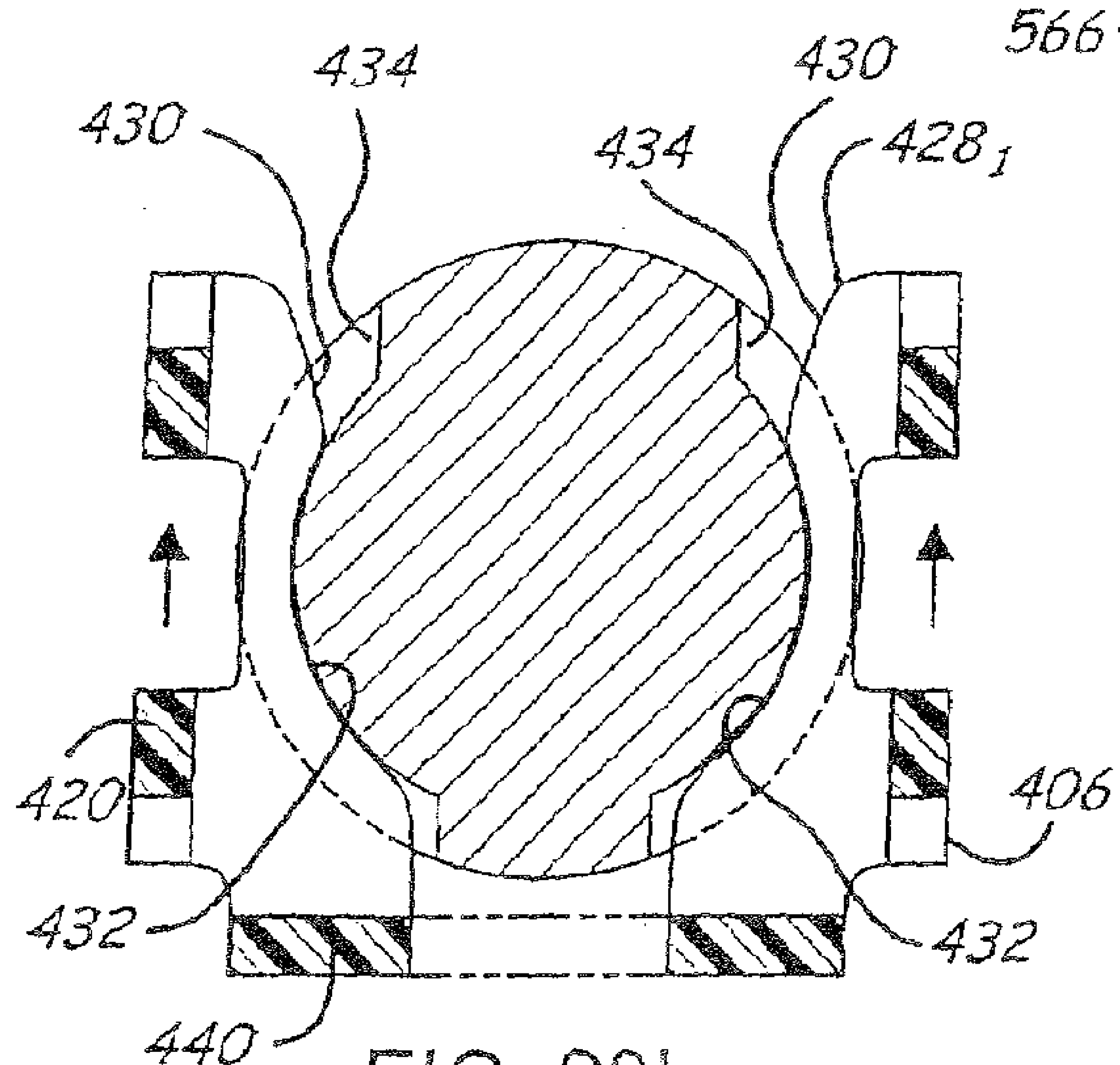

FIG. 23b

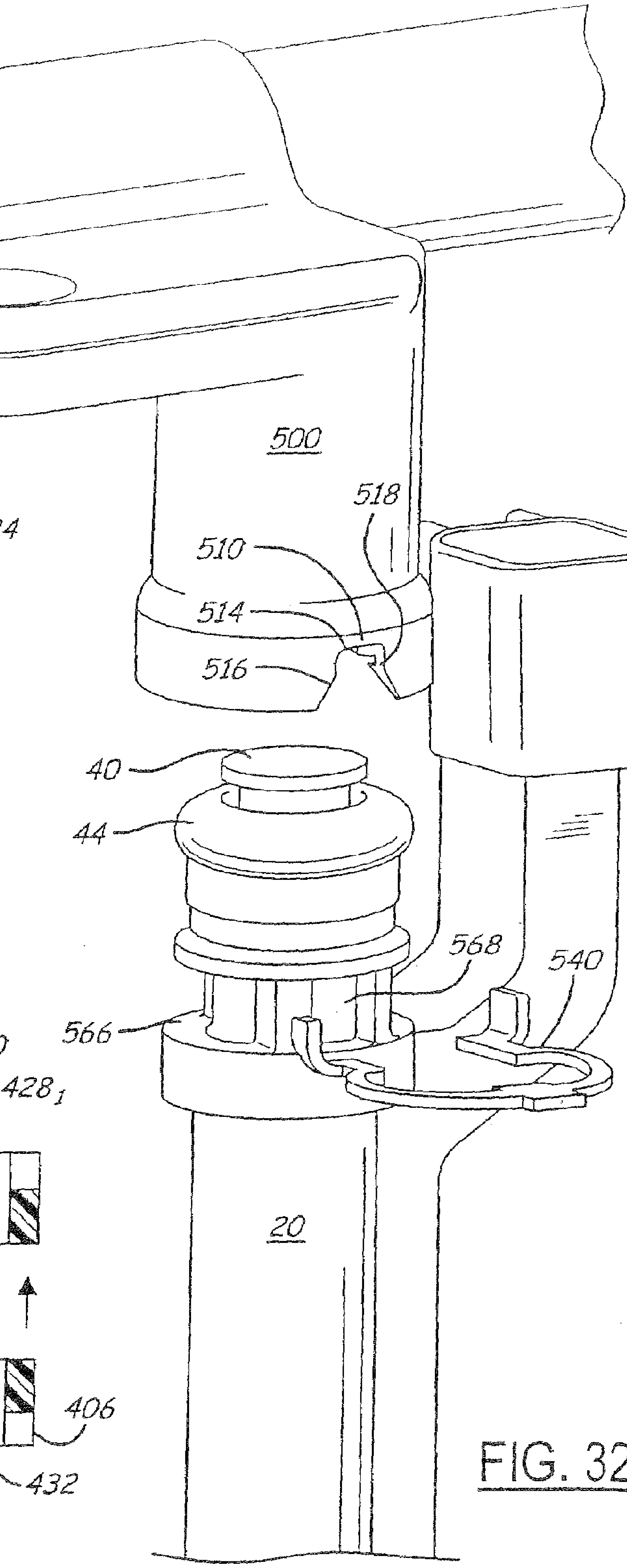

FIG. 32

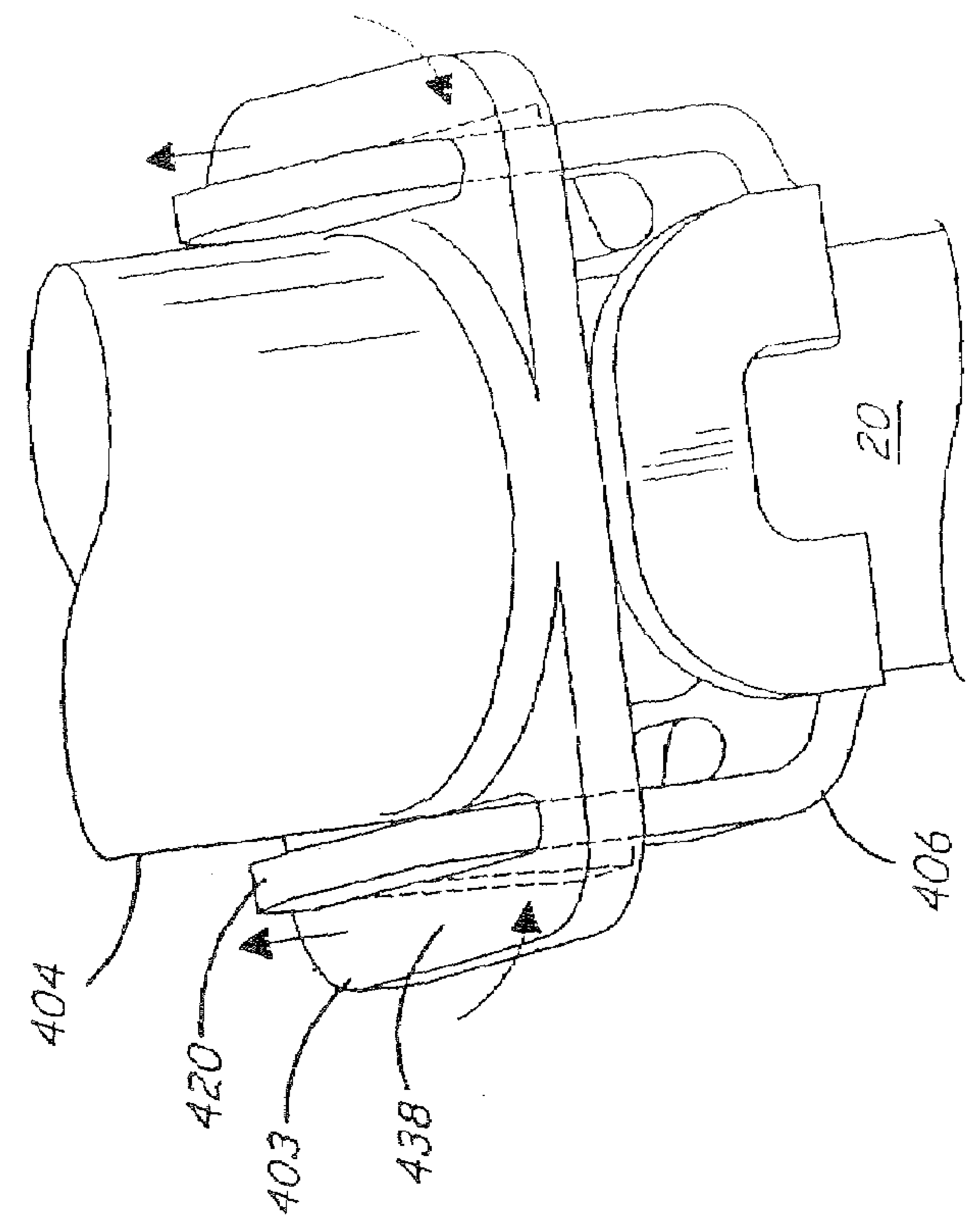

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FIG. 25

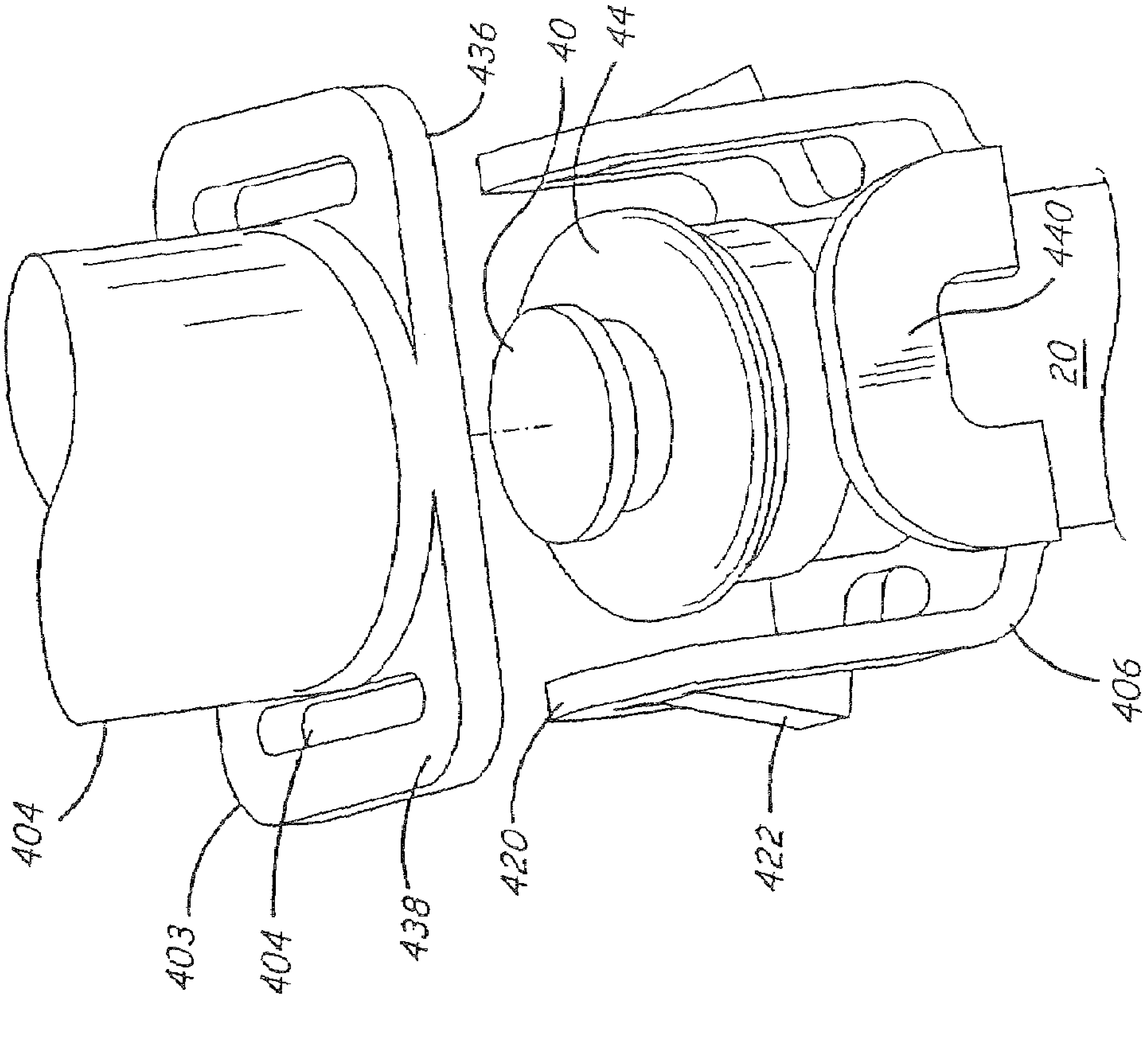

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FIG. 24

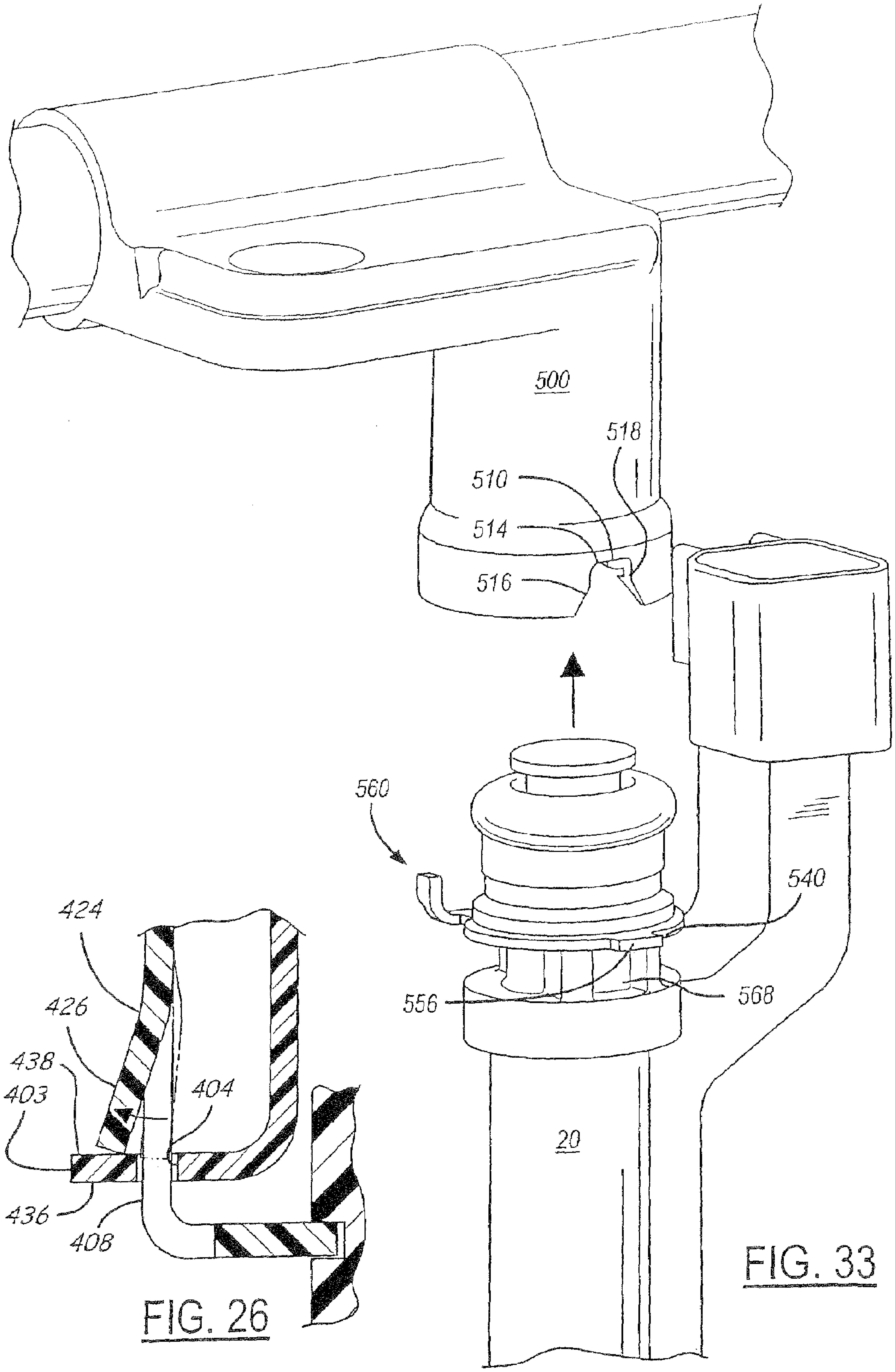
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FIG. 33

FIG. 26

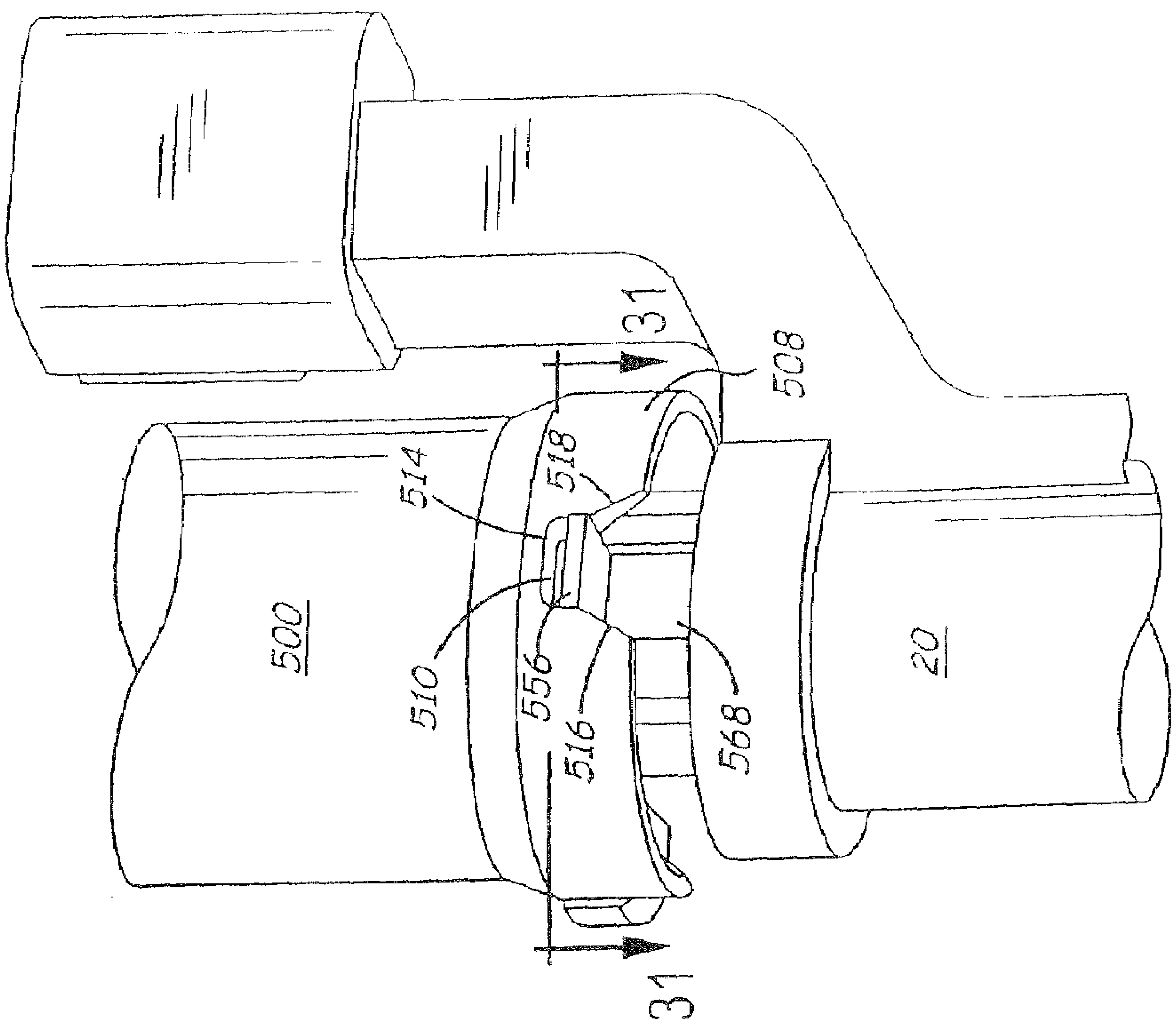
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FIG. 28

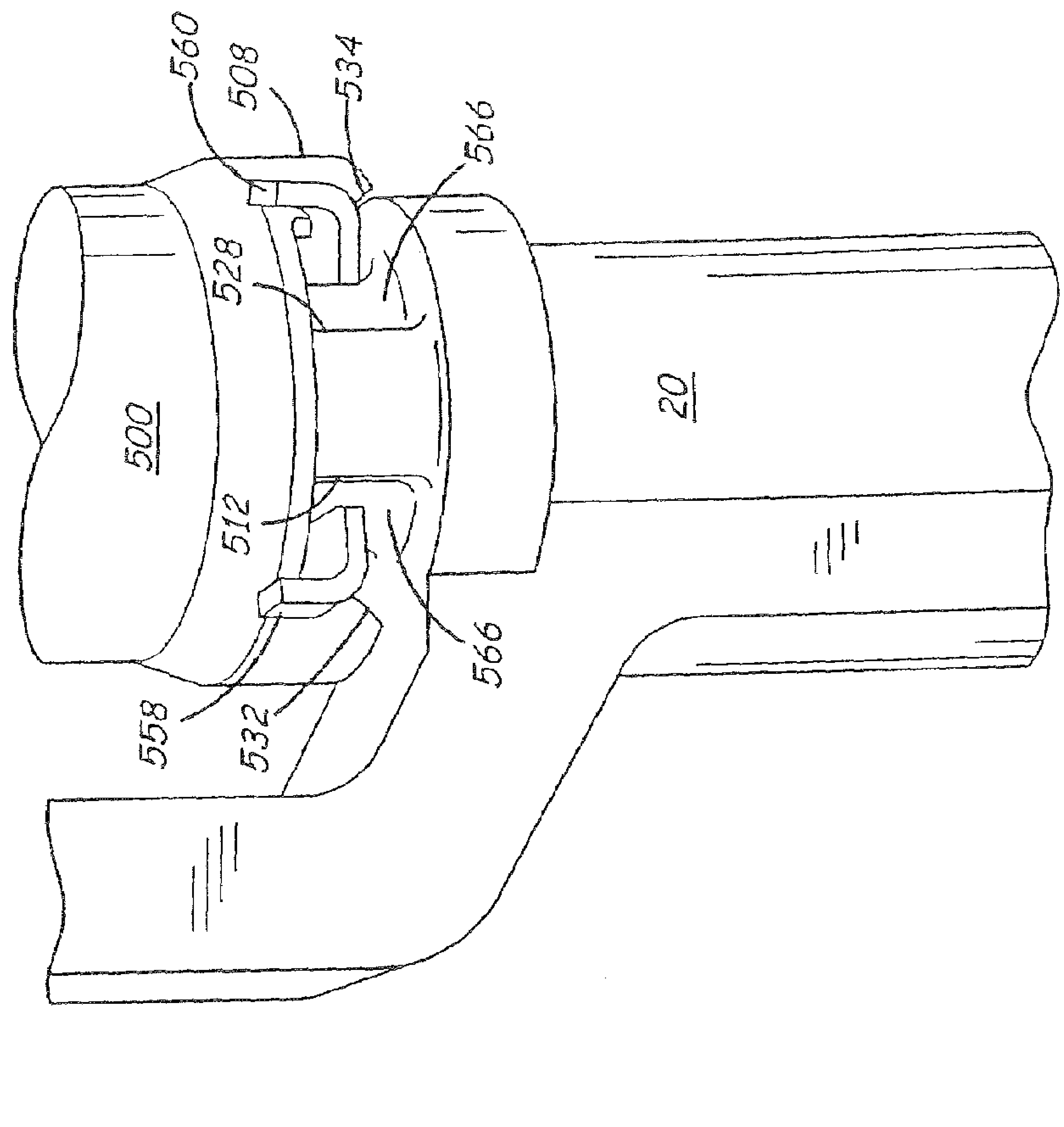
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FIG. 27

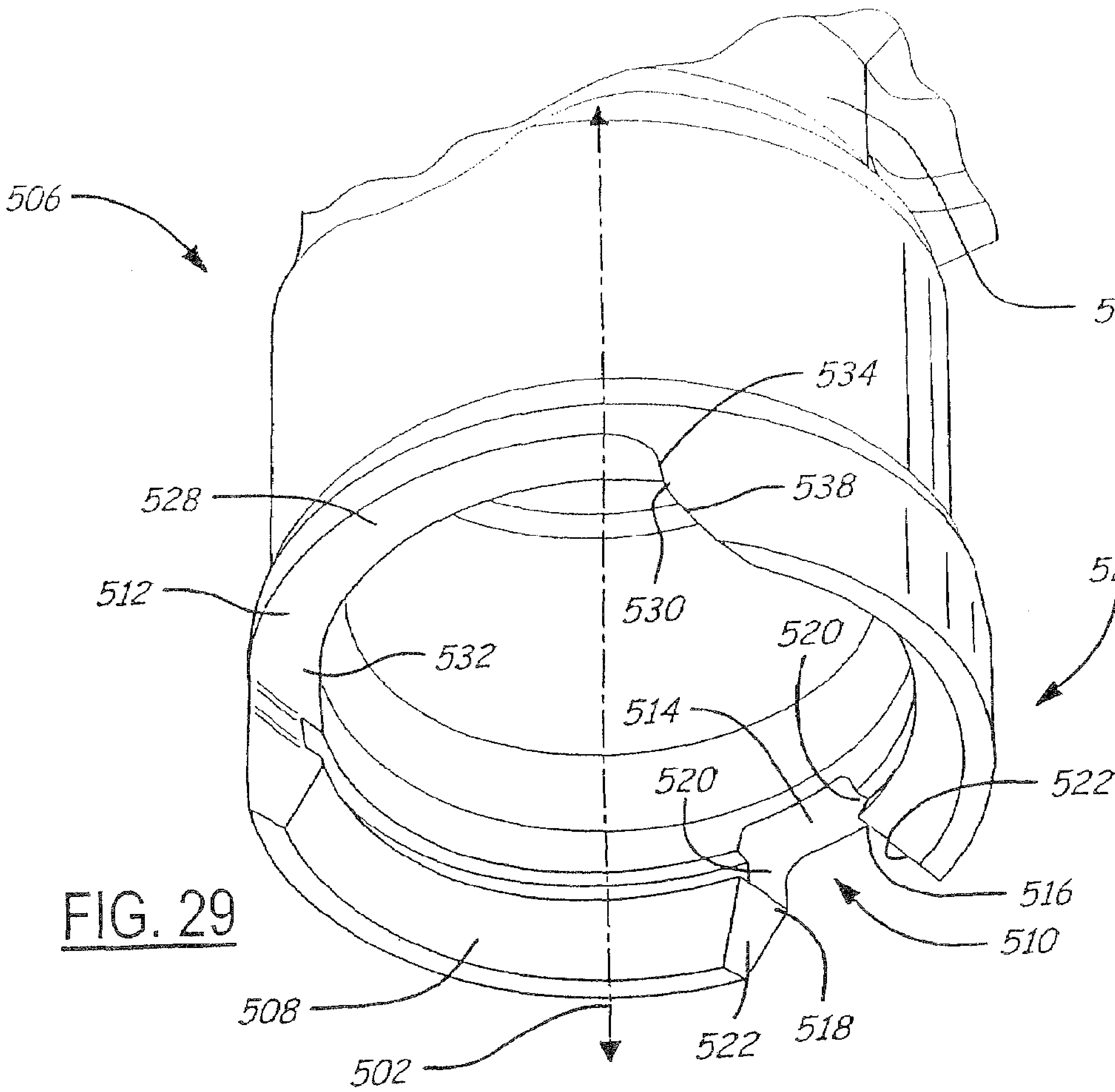
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FIG. 29

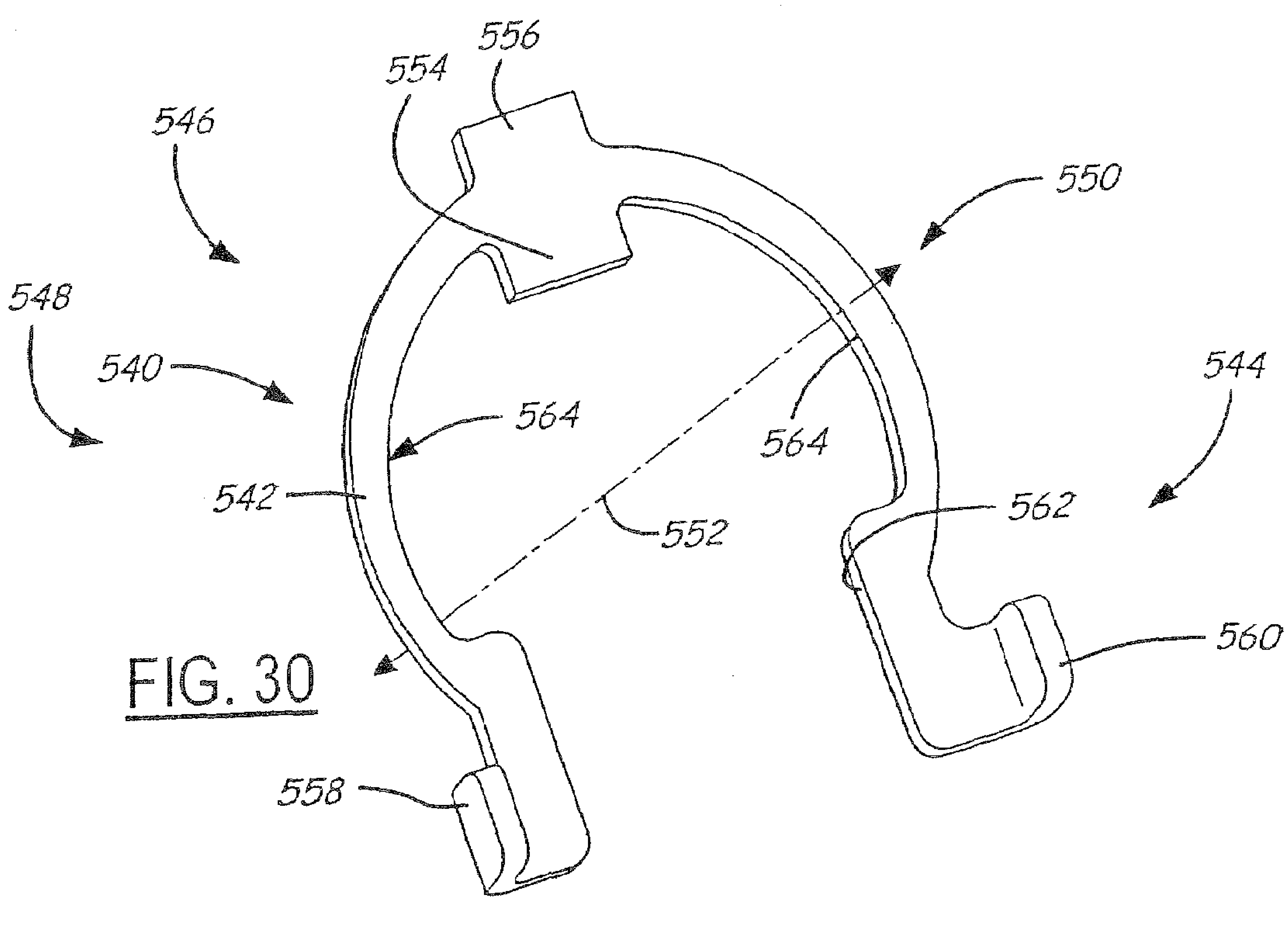
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FIG. 30

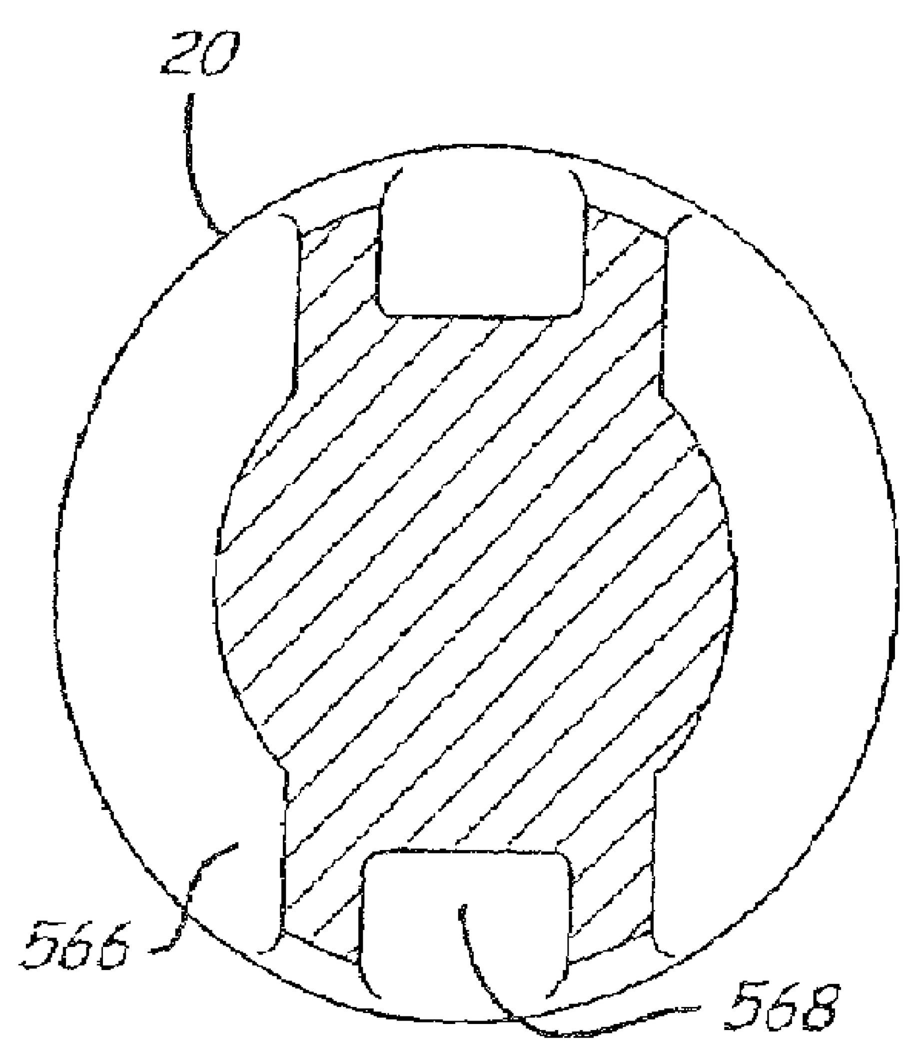

FIG. 31a

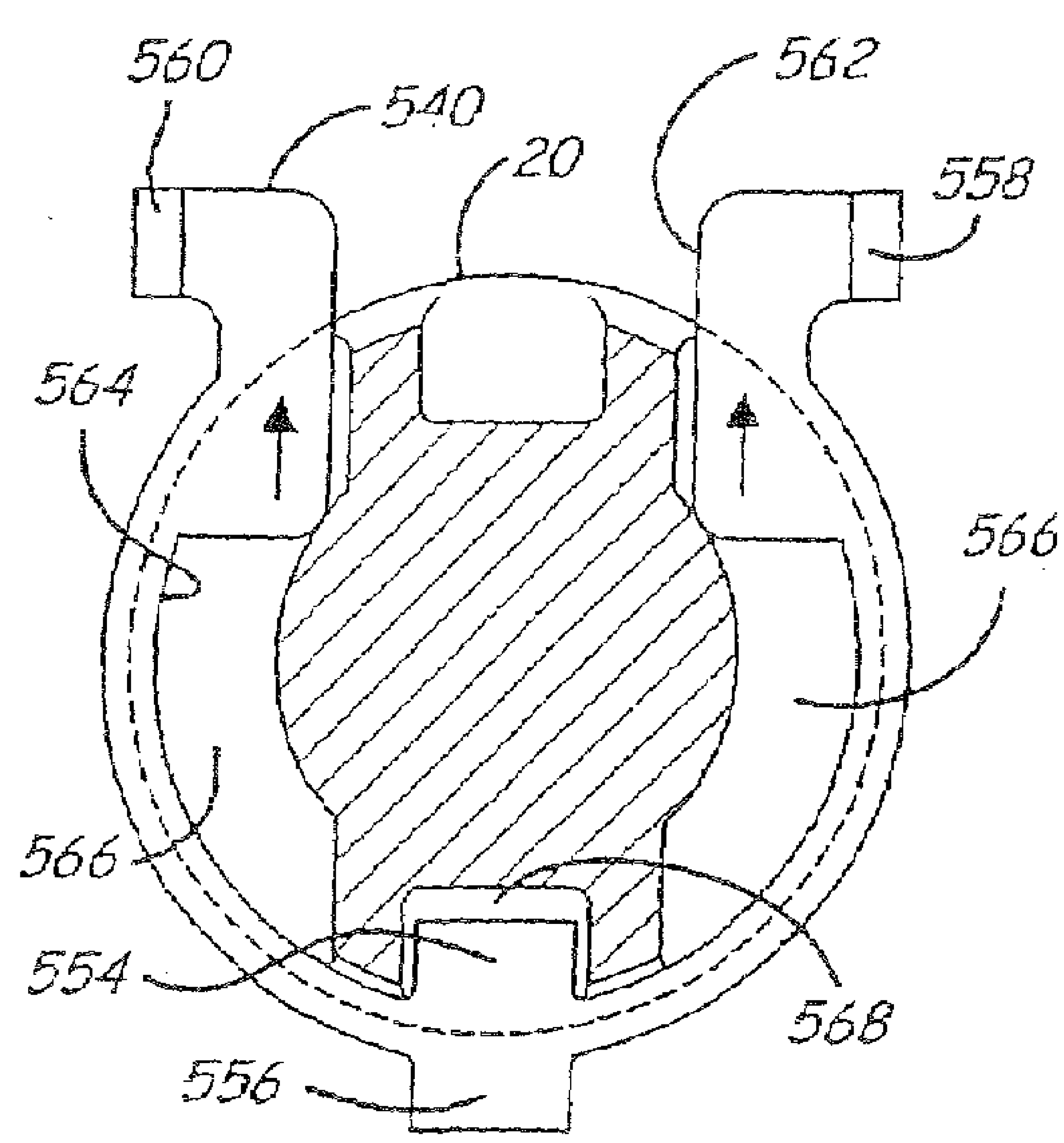

FIG. 31b

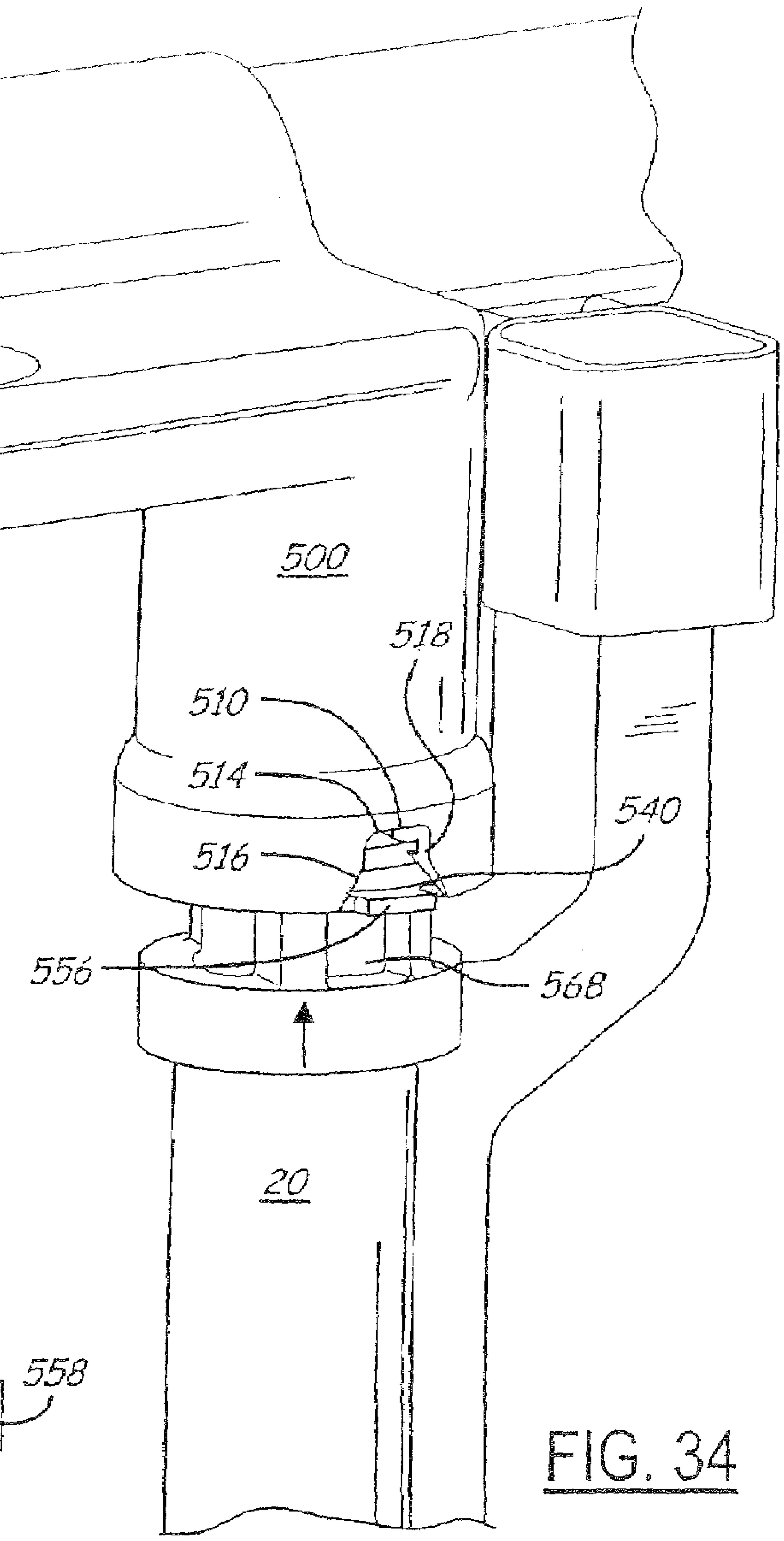

FIG. 34

FUEL INJECTOR RETENTION CLIP

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a Divisional of U.S. patent application Ser. No. 11/361,550 entitled Fuel Injector Retention Clip filed on Feb. 24, 2006 now U.S. Pat. No. 7,360,524 and currently pending, which is a Continuation-in-Part of Application No. 11/003,059 filed Dec. 3, 2004, now U.S. Pat. No. 7,159,570 entitled Fuel Injector Retention Clip. Both U.S. patent application Ser. No. 11/361,550 and U.S. Pat. No. 7,159,570 are hereby incorporated by reference in their entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a fuel delivery system arrangement for connecting an electric operated fuel injector between a fuel rail and an air intake of a spark-ignited, internal combustion engine.

2. Discussion of Related Art

Spark-ignited, fuel-injected internal combustion engines are often used in automotive vehicles. Fuel is injected into an intake system of such an engine by electric operated fuel injectors of a fuel rail (sometimes referred to as a fuel manifold) assembled to the engine.

Targeted types of fuel injectors inject fuel into the vehicle engine in a direction, or directions, that are other than along the fuel injector axial centerline. A split stream fuel injector is an example of a targeted fuel injector. When a targeted fuel injector is used in an engine, the fuel injector has to have a particular angular or circumferential orientation about its centerline so that the direction(s) of fuel injection will be properly targeted. Improperly targeted fuel injectors may derogate engine performance and/or compliance with applicable vehicle emission requirements.

Proper targeting of a fuel injector typically requires a proper axial positioning of the fuel injector. This is typically achieved by positioning the fuel injector nozzle, which contains one or more metering orifices from which fuel is injected into an engine, in a fixed geometric relation to a socket receptacle of the engine intake system into which the nozzle is inserted in a sealed manner. When a fuel rail containing fuel injectors that have been properly circumferentially located in respective outlet cups of the fuel rail is assembled to an engine that has injector-receiving socket receptacles, the act of inserting the nozzles into properly sealed relationship with the socket receptacles can complete proper targeting of the fuel injectors. The achievement of the correct circumferential location of the fuel injector to the fuel rail outlet cup is referred to as "clocking" the fuel injector.

A fuel rail may comprise attachment features, aperture brackets for example, with which threaded fasteners are associated to fasten the fuel rail to an engine. Once the fuel injector nozzles have seated in properly targeted positions in the socket receptacles, a need for further tightening of such fasteners in order to secure the fuel rail to the engine may induce undesired stress, distortion and/or movement. For example, if fuel injector nozzles have been seated in properly targeted positions in respective socket receptacles in engine air intake manifold runners before the fuel rail attachment fasteners have been fully torqued, the fuel rail may distort in some way, and/or there may be some relative movement between some component parts, as the fasteners are finally tightened to full installation torque. With prevailing manufacturing methods and dimensional tolerances of manufactured

parts, it seems that the possibility of such distortion, or movement of component parts, at time of fuel rail assembly to an engine, cannot be totally foreclosed in all circumstances.

It has been known to mechanically retain a fuel injector in a fuel rail outlet cup by a retention clip that constrains the two against any substantial movement, both circumferentially and axially. A fuel rail that incorporates such a capability may improve serviceability should it become necessary to remove the fuel rail from an engine and thereafter reattach it.

Due to the enhanced stringency of vehicle emission requirements and the use of four valve cylinder heads with two intake ports, it is now more important than ever to insure the fuel injectors are properly clocked. Therefore the requirements that fuel injectors be properly clocked when inadvertently twisted during assembly or maintenance operations are greater than that previously required. Many prior fuel delivery system arrangements retain the fuel injector to the cup with a double C-type clamp clip. The double C-type clamp clip has a primary C clamp which engages an arcuate slot of the injector body. The primary C clamp retains the injector body in a generally axial direction. A secondary C clamp is typically provided which extends generally perpendicular from the primary C clamp. The secondary C clamp typically has slots or projections which interact with a flange portion of an outlet cup to make it a click-on type connection. The secondary C clamp will typically have a contact surface to prevent rotation of the fuel injector body with respect to the fuel injector outlet other than its desired angular position. An example of such a clip is shown in U.S. Pat. No. 5,040,512.

There has been a tendency from many of the prior clips to lose their retention with the fuel injector body when the fuel injector is inadvertently twisted during a maintenance operation or during a misassembly.

It is desirable to provide an improved fuel delivery system wherein the clip is less susceptible to being splayed open whenever a fuel injector is torqued inadvertently.

SUMMARY OF THE INVENTION

A fuel delivery system is provided. A fuel delivery system in accordance with the present invention comprises a fuel rail having an outlet opening and an outlet cup having an inlet that is insertable into the outlet opening. The cup further includes a flange wherein the flange includes at least one tab extending therefrom. The cup still further defines a vertical axis extending through the center of the inlet of the cup. The fuel delivery system further includes a fuel injector having a body with an inlet insertable within the cup. The fuel delivery system still further includes a clip having a base. The base includes an inner peripheral surface, at least a portion of which is configured for engagement with the fuel injector body when the clip is assembled with the fuel injector. The clip further includes at least one arm extending from the base in a axial direction relative to the vertical axis, the arm also including an axially extending finger configured for spring engagement with the tab of the flange of the cup. The clip is operative to limit the axial and radial movement of the fuel injector when the fuel injector is assembled with the clip and inserted in the cup.

A fuel injector clip for use in a fuel delivery system is also presented.

Other features of the invention will become more apparent from a review of the ensuing drawings and description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of the internal combustion engine of the present invention.

FIG. **2** is an enlarged perspective partially sectioned view of the fuel delivery system shown in FIG. **1**.

FIG. **3** is a sectional view of a fuel injector shown in FIGS. **1** and **2**.

FIG. **4** is a perspective view of a clip utilizing the fuel delivery system shown in FIGS. **1-3**.

FIG. **5** is a perspective partially sectioned view of the fuel delivery system shown in FIGS. **1-4**.

FIG. **6** is a partial side elevational view of an alternate preferred embodiment fuel delivery system according to the present invention.

FIG. **7** is a partial sectional view of the fuel delivery system shown in FIG. **6**.

FIG. **8** is a top plan view of an alternate preferred embodiment clip to that shown in FIG. **4**.

FIG. **9** is a perspective view of another alternative preferred embodiment clip to that shown in FIG. **4**.

FIG. **10** is a side elevational view of the clip shown in FIG. **9**.

FIG. **11** is an elevational view of the clip shown in FIGS. **9-10** utilized to retain a fuel injector to a fuel rail outlet cup with portions of the cup removed for clarity of illustration.

FIG. **12** is a top plan view of the fuel rail cup utilized in the fuel delivery system shown in FIG. **11**.

FIG. **13** is a perspective view of another alternative preferred embodiment clip to that shown in FIG. **4**.

FIG. **14** is an enlarged partially sectioned perspective view of an alternate embodiment of the fuel delivery system shown in FIG. **2**.

FIG. **15** is a perspective view of an exemplary embodiment of a fuel rail outlet cup shown in FIG. **14**.

FIG. **16** is a perspective view of a fuel injector clip shown in FIG. **14** utilized to retain a fuel injector in the fuel rail outlet cup shown in FIG. **15**.

FIGS. **17***a* and **17***b* are cross section views of the injector shown in FIG. **14** with and without the clip of FIG. **16** attached thereto taken along the lines **17-17** in FIG. **14**.

FIG. **18** is an enlarged partially sectioned perspective view of the injector and injector clip combination being inserted into the outlet cup shown in FIG. **15**.

FIG. **19** is an enlarged partial cross section view of a portion of the clip shown in FIG. **16** showing the progression of the engagement of the clip with a portion of the cup shown in FIG. **15** along line **19-19** in FIG. **14**.

FIG. **20** is an enlarged partially sectioned perspective view of an alternate embodiment of the fuel delivery system shown in FIG. **2**.

FIG. **21** is a perspective view of an exemplary embodiment of a fuel rail outlet cup shown in FIG. **20**.

FIG. **22** is a perspective view of a fuel injector clip shown in FIG. **20** utilized to retain a fuel injector in the fuel rail outlet cup shown in FIG. **21**.

FIGS. **23***a* and **23***b* are cross section views of the injector shown in FIG. **20** with an without the clip of FIG. **22** attached thereto taken along the line **23-23** in FIG. **20**.

FIGS. **24** and **25** are enlarged perspective views of the injector and injector clip combination being inserted into the outlet cup shown in FIG. **21**.

FIG. **26** is an enlarged partial cross section view of a portion of the clip shown in FIG. **22** showing the progression of the engagement of the clip with a portion of the cup shown in FIG. **21** along line **26-26** in FIG. **20**.

FIGS. **27** and **28** are enlarged partially sectioned perspective views of an alternate embodiment of the fuel delivery system shown in FIG. **2**.

FIG. **29** is a perspective view of an exemplary embodiment of a fuel rail outlet cup shown in FIGS. **27** and **28**.

FIG. **30** is a perspective view of a fuel injector clip shown in FIGS. **27** and **28** utilized to retain a fuel injector in the fuel rail outlet cup shown in FIG. **29**.

FIGS. **31***a* and **31***b* are cross section views of the injector shown in FIGS. **27** and **28** with and without the clip of FIG. **30** attached thereto taken along the line **31-31** in FIG. **28**.

FIGS. **32-34** are enlarged perspective views of the injector and injector clip combination being coupled together and inserted into the outlet cup shown in FIG. **29**.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** illustrates a spark-ignited, internal combustion vehicle engine **3** having an arrangement of a fuel delivery system **7** according to the present invention. The vehicle engine **3** as schematically shown has an engine block **10**. The engine block **10** has a bank of combustion chambers **12**. The combustion chambers **12** are fluidly connected with runners **14** of an air intake manifold **16**. Connected between the air intake manifold **16** and a pressurized fuel rail **18** are a series of fuel injectors **20**. The fuel injectors **20** meter fuel from the fuel rail **18** to the runners **14**. In another embodiment of the present invention (not shown), the fuel injectors **20** are inserted with a passage connecting them directly with the combustion chambers **12**. Typically the fuel rail **18** will be connected to the intake manifold **16** by a series of brackets (not shown). The fuel injectors **20** are typically top feed electric operated type fuel injectors. The fuel injectors may be single or multiple orifice type fuel injectors and typically will be directional type fuel injectors wherein the angular position of the fuel injectors about its longitudinal axis should be aligned with a predetermined direction to ensure proper delivery of fuel into the runners **14** of the air intake manifold **16**.

Referring additionally to FIGS. **2**, **3**, **4** and **5** the fuel delivery system **7** of the present invention as mentioned previously includes the fuel rail **18**. The fuel rail **18** has an outlet opening **24**. An outlet cup **26** has a narrow portion **28** and is sealably inserted within the aforementioned fuel rail outlet opening **24**. The outlet cup **26** also has an enlarged portion **30**. Towards a bottom outlet end, the outlet cup **26** has a flange **32**. In the embodiment shown, the flange **32** is generally perpendicular but in other embodiments the flange can be angled upward (FIGS. **6** and **7**) or downward (not shown). The flange **32** of the outlet cup has a slot **34**. The slot **34** also extends to a short portion of the enlarged portion **30** which is most adjacent to the flange **32**.

The fuel injector has a body inlet portion **40** which has an inlet opening **42** extending therethrough. The inlet portion **40** is insertable within the cup **26**. An O-ring **44** is sealably engaged with the inlet portion **40** of the fuel injector and additionally is sealably engaged with an interior inner diameter **46** of the cup. A mid portion **48** of the injector has slot grooves **50** (FIG. **5**) providing flats **52**. A bottom end **54** of the fuel injector body is sealably mounted by an O-ring **56** within an opening **58** of the intake manifold **16** which intersects with the runner **14**.

The fuel delivery system includes an arcuate clip **60**. The clip **60** functions to radially and axially retain the fuel injector **20** to the cup **26** and also functions to clock or to angularly orientate the fuel injector **20** to ensure its proper angular positional alignment along its longitudinal axis. The clip **60** has an outer periphery or circumference **62**. The outer circumference **62** will be sized to be slightly greater than that than the inner diameter **46** of the cup when the clip is in its free state and slightly less when circumferentially compressed for insertion into the cup **26**. The clip **60** has an inner peripheral or circumferential surface **64**. The inner circumferential surface **64** of the clip has non-relative torsional engagement with the mid portion **48** of the fuel injector. The inner circumferential surface **64** has flats **66** which engage the flats **52** of the injector body. The clip **60** has an open end between the contact points **68**. The distance between the contact points **68** will typically be slightly less than or the same as the width between the flats **52** of the injector body mid portion and the injector body mid portion will only come within the interior of the clip **60** by spreading apart the contact points **68**. The clip **60** also has radially extending arms **70**. Radially extending arms **70** each have two fingers **72** which are positioned on top of the cup flange **32**.

During the assembly operation the contact points **68** are spread apart or wedged apart and ride upon the flats **52** of the fuel injector body until such time that the flats **66** are allowed to engage with the flats **52**. A top or extreme sectional end of the injector body mid portion noted as item **76** (FIG. **3**) can be purposely cut off so that the flats **66** cannot engage with the flats **52**. Therefore an assembler by tactual touch alone will have confirmation that the fuel injector is not properly clocked and will therefore turn the fuel injector around **180** degrees to ensure its proper orientation with respect to the clip **62**. The clip will be slightly compressed by appropriate tooling after being engaged with the fuel injector mid portion. The arms **70** are then aligned with the slots **34** of the injector cup and the arm **70** and finger **72** are deformed to place an orifice contact surface **78** on top of the flange **32**. The fuel injector will be clocked in the correct position and the finger with contact with the flange **32** will axially and radially retain the fuel injector body in position. The slot floor and ceiling is juxtaposed by the thickness of the clip **60**. The height of the slots **50** over and above that of the vertical height of the clip **60** will determine the axial play of the fuel injector with respect to the fuel rail **18**.

When fuel injector **20** is assembled with clip **60** and inserted into cup **26**, clip **60** is restrained within cup **26**, thereby preventing clip **160** from opening. Accordingly, any inadvertent attempt to twist the fuel injector **20** will cause the clip to open up and engage the interior diameter **46** of the cup. The clip **60** will not be allowed to open up to release the fuel injector **20** unless it or the cup **26** is deformed, which will require substantial force. To release the fuel injector **20** for maintenance, the arms and fingers **72** will be deformed and removed through the slots **34**.

Referring to FIGS. **6** and **7** an alternate preferred embodiment of the present invention has a clip **90**. Clip **90** is substantially similar to clip **60** except it has a descending arm **92**. A cup **94** utilized with the clip **90** has a generally upward angle flange **96** with a slot **98**. The arm **92** has two projecting fingers **93** which nest between the flange **96** and the enlarged portion **102** of the cup.

Referring to FIG. **8** an alternate preferred embodiment clip **110** has a main body **112** substantially similar to that aforedescribed for the clip **60**. The clip **110** is used with a cup **26**, as shown in FIGS. **2** and **5**. Additionally, the clip **60** has arms **114** having spring fingers **116**. The fingers **116** compliantly engage against the outer perimeter of the cup enlarged portion **30** while additionally resting upon the cup flange **32**.

Referring to FIGS. **9-12**, an alternate preferred embodiment fuel delivery system includes a clip **160**. The clip **160** functions to radially and axially retain a fuel injector **120** to the cup **126** and also functions to clock or to angularly orientate the fuel injector **120** to insure its proper alignment along its longitudinal axis. The clip **160** has an outer periphery **162**, an inner peripheral surface **164**, flats **166** and an open end between contact points **168**, essentially similar to or identical to the aforedescribed items in regards to the clip **60** previously described.

Clip **160** has radially extending arms **170** which include a downwardly extending portion **171**, a base portion **173**, an upward extending portion **175** and a downwardly extending portion **177**. The arms have a flared finger **172** which has a generally horizontal downward facing contact surface **174**. The shoulder also provides a generally vertical radially inward contact surface **179**.

The cup flange **132** has generally radial projections **128** (shown only in FIG. **12**). The projections **128** set the radial position of the clip **160** with respect to the cup **126**. The arms **170** have spring engagement with the flange **132** of the cup and the spring engagement has both a vertical and horizontal component due to the contact of the contact surfaces **177**, **174** with the flange **132**. Accordingly, when fuel injector **20** is assembled with clip **160** and inserted into cup **126**, the arrangement of arms **170** and flange **132**, combined with a portion of clip **160** being disposed within cup **126**, restrains clip **160** and prevents it from opening. When it is desirable to disassemble a fuel injector from the fuel rail, the downward extending portion **177** of the clip can be pushed outward to release the clip from the cup flange **132**.

Referring to FIG. **13** an alternate preferred embodiment clip **200** is provided. The clip **200** has a wishbone bend **201**. The bend **201** allows the clip to be removable by hand or without the use of specialized tooling. The wishbone bend **201** also allows the clip **200** to bend without permanent deformation therefore it can be reused. The clip **200** has bent over arms **202** which after installation extend over the top of the flange. The reminder to the clip **200** is similar if not identical to the clip **60**.

FIGS. **14-19** illustrate yet another embodiment of fuel delivery system **7** (best shown in FIG. **2**). FIG. **14** illustrates a partial perspective view of an assembled fuel delivery system in accordance with this embodiment of the invention. In this embodiment, fuel delivery system **7** (best shown in FIG. **2**) includes an outlet cup **300** that is insertable into outlet opening **24** of fuel rail **18**.

With reference to FIG. **15**, cup **300** defines a vertical axis **301** extending therethrough, has an inlet **302** at a first axial end of cup **300** and that is insertable into fuel rail outlet opening **24**. Cup **300** is configured to receive the inlet portion **40** of a fuel injector **20**. As shown in FIG. **18** and as discussed above, an O-ring **44** is sealably engaged with inlet portion **40** and is configured to be sealably engaged with an interior portion of cup **300**. Cup **300** further includes a flange **303**. Flange **303** includes a pair of tabs **304** disposed at diametrically opposite sides of cup **300**. Tabs **304** extend upwards towards the first axial end, away from flange **303** at a predetermined angle. Tabs **304** each include an inner surface **306** and an outer surface **308**.

With reference to FIG. **16**, fuel delivery system **7** further includes a fuel injector clip **310**. Clip **310** has a base **311**, which in turn includes an open end **312**, a closed end **314** opposite open end **312**, a first side **316** and a second side **318** opposite first side **316**. Clip **310** defines a vertical axis **317** extending through the center thereof, and further comprises at least one arm **320** extending upwards in an axial direction relative to axis **317**. Preferably, however, clip **310** comprises a pair of arms **320**, one on either side **316**, **318** of clip **310**. It should be noted that clips having fewer or more arms remain within the spirit and scope of the present invention. In one preferred embodiment, each arm **320** takes the form of an upside-down "U", with a finger **322** extending downwards from the center of the base portion of the "U" in an axial direction relative to axis **317**. Finger **322** has an inner surface **324**, an outer surface **326**, a generally vertical portion **328** that is substantially parallel to arm **320**, and a generally angled portion **330** that angles from a vertical portion **328** towards the inner periphery of clip **310**, and base **311** in particular, at a predetermined angle that, in one preferred embodiment, is equal to the angle of tabs **304**. Fingers **322** are configured such that when fuel injector **20** is coupled with clip **310** and inserted into cup **300**, each finger **322** "snaps" over and engages with a corresponding tab **304** so as to retain injector **20** within cup **300** (best shown in FIGS. **18** and **19**).

With continued reference to FIG. **16**, base **311** of clip **310** includes an inner peripheral surface **332**. Inner surface **332** includes a pair of angled portions **334** disposed at open end **312** of clip base **311** and a pair of arcuate recessed portions **336**, one of which is located on side **316** of clip **310** and the other of which is located on side **318** of clip **310** (not shown). Angled portions **334** are such that the opening of clip base **311** tapers inwardly (i.e., reducing the width of the opening) from the radial outermost point $\mathbf{332_1}$ of inner surface **332** to a point $\mathbf{332_2}$ disposed at a first end of each recessed portion **336**. Recessed portions **336** are configured in size, shape and location on clip **310** to engage corresponding mating grooves **338** in mid-portion **48** of the body of fuel injector **20** (best shown in FIGS. **17***a*-**17***b*). Grooves **338** are disposed about the outer circumference of the body of fuel injector **20** at diametrically opposite sides of injector **20** and have a slightly greater arcuate length than that of the arcuate portions **336** of clip **310**.

With reference to FIGS. **14** and **17***b*-**19**, the coupling of clip **310** and injector **20** together (FIG. **17***b*), and the insertion of the clip/injector combination into cup **300** (FIGS. **14** and **18**-**19**) will be described. As shown in FIG. **17***b*, to assemble clip **310** and injector **20** together, the inner surface **332**, and arcuate portions **336** in particular, are radially aligned relative to axis **317** with grooves **338** of injector **20**. Clip **310** is then pushed and slid onto injector **20** in a radial direction. As clip **310** is pushed against the body of injector **20**, injector **20** slides against angled portions **334** of inner surface **332**, forcing the opening at open end **312** to deflect and widen to accommodate the size of injector **20**. Once recessed arcuate portions **336** and grooves **338** meet and are aligned, the arcuate portions **336** are seated in grooves **338**. Once clip **310** is engaged with grooves **338** of injector **20**, the opening of clip **310** reflects back to at least close to its original width. To remove injector **20** from clip **310**, the opening at open end **312** is pulled open and the injector is removed.

With reference to FIG. **18**, once clip **310** and injector **20** are assembled together, the clip/injector combination is inserted into cup **300**. When the combination is inserted, fingers **322** of clip **310** are aligned with tabs **304**. As the combination is pressed into cup **300** in an axial direction relative to axis **301**, the inner surface **324** of each finger **322** engages the outer surface **308** of the respective tab **304**.

With reference to FIG. **19**, as the combination continues to be inserted, fingers **322** continue to ride along tabs **304** in a camming fashion and the force applied to fingers **322** by tabs **304** deflects fingers **322** in a radially outward direction relative to the interior of cup **300**. This deflection continues until the end or bottom of fingers **322** is reached and the engagement between the inner surface **324** of fingers **322** and the outer surface **308** of tab **304** is broken. At the instant this engagement is broken, fingers **322** decompress and snap over the respective tabs **304** such that the outer surfaces **326** of fingers **322** are spring engaged with the respective inner surfaces **306** of tabs **304**. Once this "snapping" occurs, injector **20** is fully inserted into cup **300**, and the engagement of fingers **322** and tabs **304** axially retains the injector in position (best shown in FIG. **14**). Accordingly, as the combination of clip **310** and injector **20** are inserted into cup **300**, fingers **322** are deflected from an original position shown in phantom lines in FIG. **19** to a deflected or engaged position shown in solid lines in FIG. **19**. Once the combination of clip **310** and fuel injector **20** are assembled with cup **300**, the arrangement of arms **320** and fingers **322** with tabs **304** of cup **300** restrains clip **310** outside of cup **300**, thereby preventing clip **310** from opening.

FIG. **16** shows that clip **310** further includes an additional member **340** disposed at closed end **314** of clip **310** extending vertically from base **311** along axis **317** that is smaller in size than arms **320**. Member **340** of clip **310** is configured to allow the closed end **314**, or back portion of clip **310**, to bend to facilitate the sliding installation of clip **310** on fuel injector **20** without permanent distortion of clip **310**. Member **340** also functions to contact the electrical connector of injector **20** to keep clip **310** from separating from injector **20** when the connector is engaged, as well as to mate against a portion of cup **300** or fuel injector **20** to prevent the injector from rotating.

When clip **310** is assembled with fuel injector **20** and fuel injector **20** is inserted into cup **300**, clip **310** limits the axial and torsional movement of fuel injector **20** and holds fuel injector **20** in place. As torque is applied to injector **20**, clip **310** will rotate slightly in the grooves **338** until it strikes the ends or limits of grooves **338**. Any further rotation past this point will apply a force to enlarge the open end **312** of base **311**. Arms **320** of clip **310** restrict this movement when engaged with the tabs **304** of cup **300**. Additionally, fuel injector **20** cannot be removed from cup **300** without disengaging clip **310** from cup **300**. Accordingly, once injector **20** is clocked, it will remain so until the clip is removed from the cup.

FIGS. **20**-**26** illustrate yet still another embodiment of fuel rail delivery system **7** (best shown in FIG. **2**) that closely resembles the embodiment depicted in FIGS. **14**-**19**, but that differs in a number of respects. FIG. **20** illustrates a partial perspective view of an assembled fuel delivery system in accordance with this embodiment of the invention. In this embodiment, fuel delivery system **7** includes an outlet cup **400** that is insertable into outlet opening **24** of fuel rail **18** (best shown in FIG. **2**).

With reference to FIG. **21**, cup **400** defines a vertical axis **401** extending therethrough, and has an inlet **402** at a first axial end that is insertable into fuel rail outlet opening **24**. Cup **400** is configured to receive the inlet portion **40** of a fuel injector **20**. As shown in FIG. **24** and as discussed above, an O-ring **44** is sealably engaged with inlet portion **40** and is configured to be sealably engaged with an interior portion of cup **400**. Cup **400** further includes a flange **403**. In the illustrated embodiment, flange **403** includes a pair of slots **404** disposed therein on diametrically opposite sides of cup **400**. It should be noted, however, that while two slots are shown in the illustrated embodiment, a flange **403** having fewer or more slots remains within the spirit and scope of the present invention.

With reference to FIG. **22**, fuel delivery system **7** further includes a fuel injector clip **406**. Clip **406** has a base **408**, which in turn includes an open end **410**, a closed end **412** opposite open end **410**, a first side **414**, and a second side **416** opposite first side **414**. Clip **406** defines a vertical axis **418** extending through the center thereof, and further comprises at least one arm **420** extending upwards in an axial direction relative to axis **418**. Preferably, however, clip **406** comprises a pair of arms **420**, one on either side **414**, **416** of clip **406**. In actuality, as will be discussed in greater detail below, the number of arms **420** is dependent upon the number of slots **404** in flange **403** of cup **400**. Accordingly, embodiments having more or fewer than two slots **404** and corresponding arms **420** remain within the spirit and scope of the present invention. In one preferred embodiment, each arm **420** takes the form of an upside-down "U," with a finger **422** extending downwards in an axial direction relative to axis **418** from the center of the base portion of the "U." As will be discussed in greater detail below, arms **420** have both a length and width that corresponds to the length and width of slots **404** so as to facilitate the insertion of arms **420** into slots **404**.

With reference to FIG. **21**, cup **400** defines a vertical axis **401** extending therethrough, and has an inlet **402** at a first axial end that is insertable into fuel rail outlet opening **24**. Cup **400** is configured to receive the inlet portion **40** of a fuel injector **20**. As shown in FIG. **24** and as discussed above, an O-ring **44** is sealably engaged with inlet portion **40** and is configured to be sealably engaged with an interior port of cup **400**. Cup **400** further includes a flange **403**. In the illustrated embodiment, flange **403** includes a pair of slots **404** disposed and contained therein on diametrically opposite sides of cup **400**. II should be noted, however, that while two slots are shown in the illustrated embodiment, a flange **403** having fewer or more slots remains within the spirit and scope of the present invention.

With continued reference to FIG. **22**, base **408** of clip **406** includes an inner peripheral surface **428**. Inner surface **428** includes a pair of angled portions **430** disposed at open end **410** of clip base **408** and a pair of arcuate recessed portions **432**, one on either side **414**, **416** of base **408**. Angled portions **430** are such that the opening of clip base **408** tapers inwardly (i.e., reducing the width of the opening) from the radial outermost point 428_1 of inner surface **428** to a point 428_2 disposed at a first end of each recessed portion **432**. As shown in FIGS. **23***a*-**23***b*, recessed portions **432** are configured in size, shape and location on clip **406** to engage corresponding mating grooves **434** in mid-portion **48** of the body of fuel injector **20**. Grooves **434** are disposed about the outer circumference of the body of fuel injector **20** at diametrically opposite sides of injector **20** and have a slightly greater arcuate length than that of the arcuate portions **432** of clip **406**.

With reference to FIGS. **20** and **23***b*-**26**, the coupling of clip **406** and injector **20** together (FIG. **23***b*), and the insertion of the clip/injector combination into cup **400** (FIGS. **20** and **24-26**) will be described. As shown in FIG. **23***b*, to assemble clip **406** and injector **20** together, the inner surface **428**, and arcuate portions **432**, in particular, are radially aligned relative to axis **418** with grooves **434** of injector **20**. Clip **406** is then pushed and slid onto injector **20** in a radial direction. As clip **406** is pushed against the body of injector **20**, injector **20** slides against angled portions **430** of inner surface **428**, forcing the opening at open end **410** to radially deflect and widen to accommodate the size of injector **20**. Once recessed arcuate portions **432** and grooves **434** meet and are aligned, the arcuate portions **432** are seated in grooves **434**. Once clip **406** is engaged with grooves **434**, the opening of clip **406** reflects back to at least close to its original width. To remove injector **20** from clip **406**, the opening at open end **410** is pulled open and the injector is removed.

With reference to FIGS. **24-26**, once clip **406** and injector **20** are assembled together, the combination is inserted into cup **400**. To do so, arms **420** of clip **406** are aligned with slots **404** in flange **403** of cup **400**. As the combination moves toward cup **400**, arms **420** are inserted into slots **404**, which, as set forth above, are sized so as to facilitate the insertion of arms **420** into slots **404**. As shown in FIG. **26**, as the clip/injector combination is inserted further, the outer surface of fingers **422** make contact with the underside **436** of flange **403**. As the combination continues to be inserted, fingers **422** continue to ride along the underside **436** and inner wall of slots **404** in a camming fashion. As shown in FIG. **25**, the force applied to fingers **422** by flange **403** deflects fingers **422** in a radially inward direction relative to the interior of cup **400** from an original position shown in solid lines to a deflected position shown in phantom lines. This deflection continues until fingers **422** are completely inserted through slots **404**, causing the engagement between the inner wall of slots **404** and fingers **422** to break. At the instant the engagement is broken, fingers **422** decompress and snap out of slots **404** in a radially outward direction. Once this "snapping" occurs, injector **20** is fully inserted into cup **400**. The engagement of fingers **422** with the top side **438** of flange **403** axially retains injector **20** in position, while the arrangement of arms **420** in slots **404** serves to radially retain injector **20** in position (best shown in FIG. **20**). Accordingly, as the combination of clip **406** and injector **20** are inserted into cup **400**, fingers **422** are deflected from an original position shown in phantom lines in FIG. **26** to an engaged position shown in solid lines in FIG. **26**. Once the combination of clip **406** and fuel injector **20** are assembled with cup **400**, the arrangement of arms **420** and fingers **422** with flange **403** of cup **400** restrains clip **406** outside of cup **400**, thereby preventing clip **406** from opening.

FIG. **22** shows that clip **406** further includes an additional member **440** disposed at closed end **412** of clip **406** extending vertically from base **408** along axis **418** that is smaller in size than arms **420**. Member **440** is configured to allow the closed end **412**, or back portion of clip **406**, to bend to facilitate the sliding installation of clip **406** one fuel injector **20** without permanent distortion of clip **406**. Member **440** also functions to contact the electrical connector of injector **20** to keep clip **406** from separating from injectors **20** when the connector is engaged, as we all as to mate against a portion of cup **400** or fuel injector **20** to prevent the injector from rotating.

When clip **406** is assembled with fuel injector **20** and fuel injector **20** is inserted into cup **400**, clip **406** limits the axial and torsional movement of fuel injector **20** and retains fuel injector **20** in place. As torque is applied to injector **20**, clip **406** will rotate slightly in the grooves **434** of injector **20** until it strikes the ends or limits of grooves **434**. Any further rotation past this point will apply a force to enlarge the open end **410** of base **408**. Arms **420** that are disposed within slots **404** of cup flange **403** restrict this movement. Additionally, fuel injector **20** cannot be removed from cup **400** without disengaging clip **406** from cup **400**. Accordingly, once injector **20** is clocked, it will remain so until the clip is removed from the cup.

FIGS. **27-34** illustrate yet another further exemplary embodiment of fuel delivery system **7** (best shown in FIG. **2**). FIGS. **27** and **28** illustrate partial perspective views of an assembled fuel delivery system in accordance with this embodiment of the invention. In this embodiment, fuel delivery system **7** includes an outlet cup **500** that is insertable into opening **24** of fuel rail **18** (best shown in FIG. **2**).

With reference to FIG. **29**, cup **500** defines a vertical axis **502** extending therethrough and has an inlet **504** at a first axial end **506** of cup **500** that is insertable into fuel rail outlet opening **24**. Cup **500** is configured to receive the inlet portion **40** of a fuel injector **20**. As shown in FIG. **32** and as discussed above, an O-ring **44** is sealably engaged with inlet portion **40** and is configured to be sealably engaged with an interior portion of cup **500**. Cup **500** further includes a rim **508**. Rim **508** includes a first slot **510** and a second slot **512** therein that are disposed on diametrically opposite sides of cup **500**. In the illustrated exemplary embodiment, slot **510** is smaller in width than slot **512**, and includes a base or bottom **514**, as well as a pair of sides **516**, **518**. Sides **516**, **518** each include a vertical portion **520** extending from base **514** in a vertical direction so as to be substantially parallel to axis **502**, thereby defining a first slot width. Sides **516**, **518** also include an angled portion **522** extending from vertical portion **520** at a predetermined angle to a second axial end **524** of cup **500**. The angled portion and, more specifically, the predetermined angle, results in the creation of a second slot width that is greater than the first slot width.

Similarly, slot **512** also includes a base or bottom **528**, as well as a pair of sides **530**, **532**. Sides **530**, **532** each include a vertical portion **534** extending from base **528** in a vertical direction so as to be substantially parallel to axis **502**, thereby defining a first slot width. Sides **530**, **532** also include an angled portion **538** extending from vertical portion **534** at a predetermined angle to second axial end **524** of cup **500**. The angled portion and, more specifically, the predetermined angle, results in the creation of a second slot width that is greater than the first slot width.

With reference to FIG. **30**, fuel delivery system **7** further includes a fuel injector clip **540**. Clip **540** has a base **542**, which in turn includes an open end **544**, a closed end **546** opposite open end **544**, a first side **548**, and a second side **550** opposite first side **548**. Clip **540** also defines a vertical axis **552** extending through the center thereof Clip **540** further includes a pair of tabs **554**, **556** protruding from either side of closed end **546** of clip base **542**. As will be described in greater detail below, tab **554** is configured for engagement with a notch in the body of fuel injector **20** when clip **540** and injector **20** are coupled together. Tab **556** is sized and configured for insertion into first slot **510** in cup **500** when the combination of clip **540** and injector **20** are inserted into cup **500**. Together, tabs **554**, **556** provide orientation of injector **20** for off centerline injector spray applications.

With continued reference to FIG. **30**, clip **540** still further includes a pair of ears **558**, **560** extending upwards in an axial direction relative to axis **552** at either side of open end **544** so as to define a width of the opening at open end **544**. As will be described in greater detail below, ears **558**, **560** are spaced a predetermined distance apart so as to correspond to the first width of slot **512**. In this arrangement, when clip **540** is assembled with injector **20** and the combination is inserted into cup **500**, ears **558**, **560** are located proximate to sides **530**, **532** of slot **512**. This arrangement provides for ears **558**, **560** to be engaged with the outer surface of cup **500** (best shown in FIG. **27**).

As illustrated in FIG. **30**, base **542** of clip **500** includes an inner peripheral surface **562**. Inner surface **562** includes a pair of arcuate recessed portions **564**, one on either side **548**, **550** of clip base **542**. As shown in FIGS. **31***a* and **31***b*, recessed portions **564** are configured in size, shape and location on clip **540** to engage corresponding mating grooves **566** in the body of fuel injector **20**. Grooves **566** are disposed about the outer circumference of the body of fuel injector **20** at diametrically opposite sides of injector **20** and have a slightly greater arcuate length than that of arcuate recessed portions **564**. As also shown in FIGS. **31***a* and **31***b*, fuel injector **20** includes a notch **568** configured to receive and engage tab **554** of clip **540** when clip **540** is coupled with injector **20**.

With reference to FIGS. **27**, **28** and **31***b*-**34**, the coupling of clip **540** and injector **20** together (FIG. **31***b*), and the insertion of the clip/injector combination into cup **500** (FIGS. **27**, **28** and **32**-**34**) will be described. As shown in FIG. **31***b*, to assemble clip **540** and injector **20** together, arcuate portions **564** are radially aligned relative to axis **552** with grooves **566** of injector **20** (best shown in FIGS. **31***b* and **32**). Open end **544** of clip **540** is then pushed and slid onto injector **20** in a radial direction. As clip **540** is pushed against the body of injector **20**, injector **20** slides against inner peripheral surface **562**, forcing the opening at open end **544** to deflect and widen to accommodate the size of injector **20**. Once recessed arcuate portions **564** and grooves **566** meet and are aligned, the recessed arcuate portions **564** are seated in grooves **566**. Additionally, once grooves **566** and arcuate portions **564** are engaged, notch **568** and tab **554** are likewise engaged such that tab **554** is seated within notch **568**. This arrangement serves, at least in part, to prevent clip **540** from being rotated about injector **20**. Once clip **540** and injector **20** are fully assembled, the opening of clip **540** reflects back to at least close to its original width. To remove injector **20** from clip **540**, the opening of clip **540** is pulled open and the injector is removed.

With reference to FIGS. **33** and **34**, once clip **540** and injector **20** are assembled together, the clip/injector combination is inserted into cup **500**. To do so, tab **556** on clip **540** is aligned with slot **510** in cup **500**, and the ears **558**, **560** are aligned with slot **512** (not shown). As the combination is pressed into cup **500**, tab **556** is inserted into slot **510**, and ears **558**, **560** are inserted into slot **512**. When tab **556** reaches the bottom **514** of slot **510**, the outer peripheral surface of tab **556** is in contact with sides **516**, **518** so as to hold clip **540** and injector **20** in place. Similarly, and simultaneously, as the clip/injector combination is pressed into cup **500**, a portion of the outer peripheral surface of each of ears **558**, **560** contact and engage the outer surface of cup **500**, thereby also serving to hold the combination in place. As discussed above, when the combination is inserted into cup **500**, ears **558**, **560** are located proximate to sides **532**, **534** of slot **512**. This arrangement, along with the arrangement of tab **554** within slot **510**, serves to prevent the rotation of injector **20** while inserted into cup **500**, and thereby limiting the axial and torsional movement of fuel injector **20**. This arrangement further keeps clip **540** from opening by restraining clip **540** within cup **500**. This arrangement still further provides a means of suspending the injector from the fuel rail in order to provide isolation from the cylinder head in an engine.

While embodiments of the present invention have been explained it will be readily apparent to those skilled in the art of the various modifications and changes which can be made from the present invention without departing from the spirit and scope of the accompanying claims.

The invention claimed is:

1. A fuel delivery system comprising:

a fuel rail having an outlet opening;

an outlet cup, said cup including an inlet that is insertable into said outlet opening and a flange wherein said flange includes at least one slot contained therein, said cup defining a vertical axis extending through the center of said inlet of said cup;

a fuel injector having a body with an inlet insertable within said cup;

a clip having a base, said base including an inner peripheral surface, at least a portion of which is configured for engagement with said fuel injector body when said clip is assembled with said fuel injector, said clip further including at least one arm extending front said base in an axial upward direction relative to said vertical axis, said arm configured for insertion in said slot of said flange of said cup, said arm including an axially downward extending finger configured for engagement with said flange of said cup, said clip operative to limit the axial and torsional movement of said fuel injector when said fuel injector is assembled with said clip and inserted in said cup.

2. A fuel delivery system in accordance with claim **1** wherein said clip has an open end and a closed end and includes an upward extending vertical member relative to said vertical axis proximate said closed end of said clip, said vertical member is configured to bend to facilitate the installation of said clip on said fuel injector.

3. A fuel delivery system in accordance with claim **1** wherein said at least one arm has an upside-down U-shape, and said finger extends downward from the center of the base of said "U".

4. A fuel delivery system in accordance with claim **1** wherein said finger includes a substantially vertical portion and a substantially angled portion relative to said vertical axis wherein said angled portion projects from said vertical portion in a radially outward direction in relation to said clip, said angled portion of said finger configured to engage said flange when said injector is inserted in said cup.

5. A fuel delivery system in accordance with claim **1**, wherein said flange of said cup has a pair of slots disposed therein and said clip has a pair of axially extending arms, each of said arms including a finger, each one of said arms configured for insertion within a corresponding one of said slots, and each one of said fingers configured for engagement with said flange.

6. A fuel delivery system in accordance with claim **5** wherein said pair of slots are disposed at diametrically opposite sides of said flange and said pair of arms are disposed at diametrically opposite sides of said clip base so as to be in alignment with said slots when said fuel injector is assembled with said clip and said fuel injector is inserted into said cup.

7. A fuel delivery system in accordance with claim **1** wherein the arrangement of said clip and said cup when said injector is inserted in said cup is operative to limit the radial expansion of said clip.

8. A fuel injector clip for use in a fuel delivery system, comprising:

a base having an open end, a closed end, and inner peripheral surface at least a portion of which is configured for engagement with the body of a fuel injector when said clip is assembled with said fuel injector, said base defining a vertical axis extending therethrough perpendicular to a horizontal plane defined by said base; and

a pair of arms extending from said base in an axially upward direction relative to said vertical axis, each of said arms including a finger extending axially downward from said arms and away from said vertical axis, said arms insertable within a pair of corresponding slots contained within a flange of a fuel outlet cup, said arms being configured to limit the radial expansion of said open end when inserted in said slots, and said fingers configured for engagement with said flange;

said clip operative to limit the axial and torsional movement of said fuel injector when said clip is assembled with said fuel injector and said fuel injector is inserted in said cup.

9. A fuel injector clip in accordance with claim **8** wherein said pair of arms are disposed at diametrically opposite sides of said clip base so as to be in alignment with said slots of said outlet cup when said fuel injector is assembled with said clip and said fuel injector is inserted into said cup.

10. A fuel injector clip in accordance with claim **8** wherein said portion of said inner peripheral surface configured for engagement with said fuel injector body is insertable into at least one groove in said body of said fuel injector.

11. A fuel injector clip in accordance with claim **8** wherein said base of said clip includes an upward extending vertical member relative to said vertical axis proximate said closed end, said vertical member configured to bend to facilitate the installation of said clip on said fuel injector.

12. A fuel injector clip in accordance with claim **8** wherein each of said pair of arms has an upside-down U-shape, and each of said fingers extends downward from the center of the base of said "U".

13. A fuel injector clip in accordance with claim **8** wherein said fingers include a substantially vertical portion and a substantially angled portion relative to said vertical axis wherein said angled portion projects from said vertical portion in a radially outward direction in relation to said body of said clip, said angled portion of said fingers configured to engage said flange when said clip is assembled with said fuel injector and said injector is inserted into said cup.

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